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ABSTRACT

Because of shortcomings in the traditional approach to instruction and learning at Waukesha County Technical Institute in Wisconsin, this research was conducted to determine the effectiveness of an alternate approach to instruction in electronics technology. The "Closed Loop Systems Approach to Instruction" developed for this study was derived from the assimilation of the works and concepts of many professional vocational educators. In order to generate the data base to accomplish Phase I and II objectives, a survey instrument was developed and mailed to 287 electronics oriented firms in three large midwest metropolitan areas. In addition, seven personal interviews were conducted using the instrument as a medium for stimulating responses. Collected evidence demonstrates that the "Systems Approach" can: (1) identify the characteristics of employed electronic technicians, (2) identify tasks performed by electronic technicians and determine educational requirements, (3) identify needed skills, (4) assess student mastery of specific skills, (5) identify the best techniques for accomplishing performance objectives, and (6) assure a relevant curriculum. Additional studies in other institutions are recommended. The survey instrument and data tables are included. (GB)

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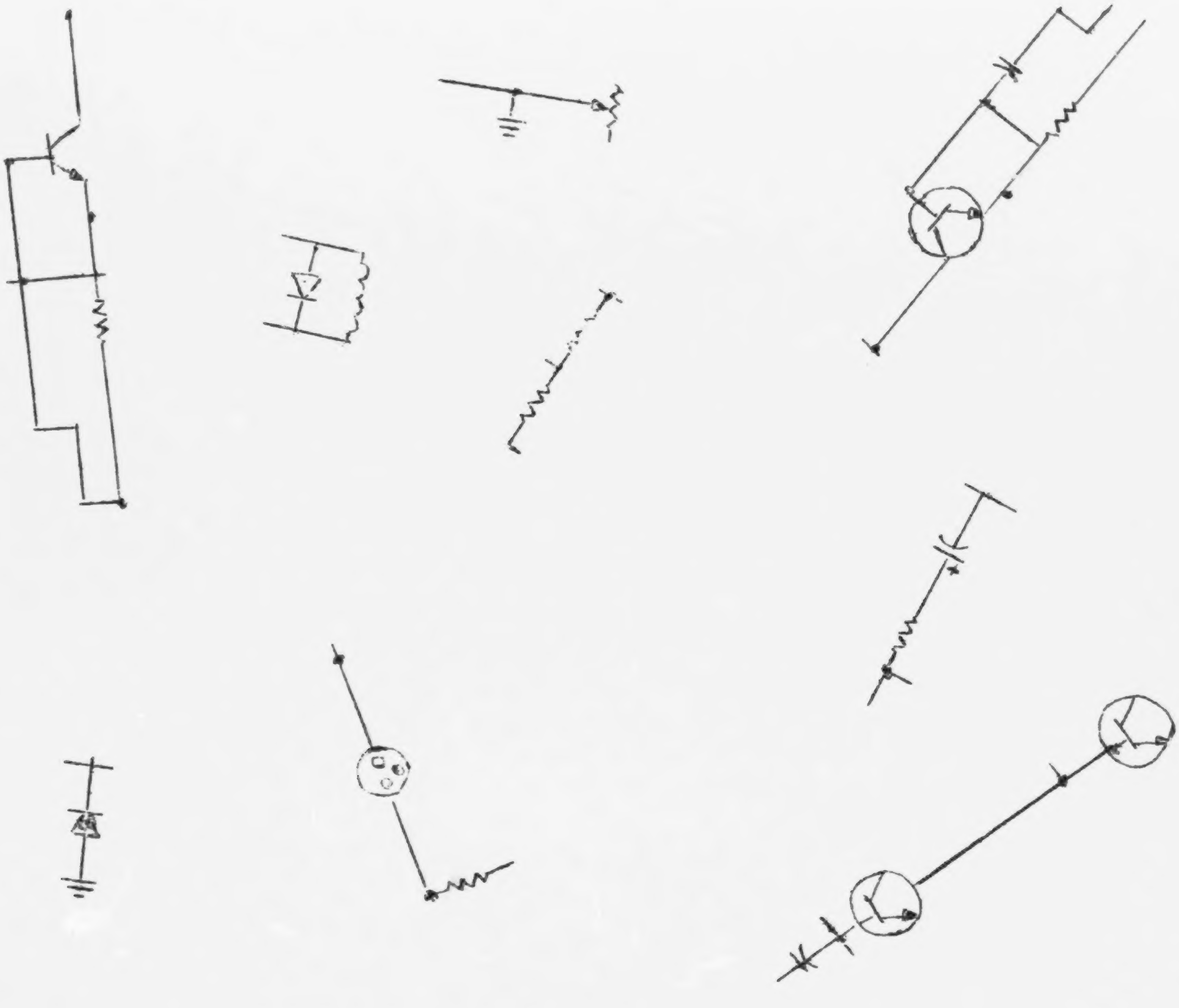
INSTRUCTIONAL SYSTEMS STUDY
ELECTRONICS TECHNOLOGY

VOLUME I



A. J. Natalizio, District Director

WAUKESHA COUNTY TECHNICAL INSTITUTE
AREA VOCATIONAL, TECHNICAL AND ADULT EDUCATION
DISTRICT #8

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ACKNOWLEDGEMENTS

TO:

Mr. William C. Littlewood, Division Chairman, for his professional competence in developing instruction for the Electronics Technology.

The Waukesha County Technical Institute Administration and Board for their cooperation in continuing the financing of this project.

The Staff of the Wisconsin State Board of Vocational, Technical and Adult Education for their foresight, advisement and time extension on this project.

Dr. Robert F. Mager whose recommendations and comments have stimulated project participants to greater ends.

George A. McGuire Curriculum Coordinator Project Director	Walter R. Winter Administrator of Research & Development Project Director

PREFACE

The 1960's have been a decade of change regarding curricular methods and materials. New approaches to learning have been investigated and technological advances have made inroads in the Field of Education. The desire of each institution to be unique has led to curricular innovations. The push for higher quality education has been another force for change.

One who has followed the events taking place will have noted little direction in these curricular changes. Probes have been made, most of them away from the traditional teacher centered classroom. The "State of the Art" in instructional methods and techniques appears to be in a period of transition. "Where do we go from here?" is an often asked question. With no absolute answers, a quest for solutions is a goal of our most progressive educational institutions.

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INTRODUCTION

This study evolved due to probes into new approaches to instruction in vocational-technical education at the Waukesha County Technical Institute. The motivation for this search stemmed from the felt shortcomings of the traditional approach to instruction; that of the self-contained teacher in the self-contained classroom. It is the experience of the project directors that the traditional approach functions in a sea of generalities. So general, in fact, that any attempt to measure results is fruitless. Educational intents have been so vaguely stated that neither the student nor the instructor are properly guided by them.

Does the traditional approach meet the needs of students? There are several good reasons to pose this question. When traditional educators are asked to prove that they are meeting the needs of the learner they are often at a loss. Instruction designed for economy and administrative control has long turned off many students. Of course, this is inevitable in that their needs were not considered in the instructional design. Allowances for individual differences has gone wanting. Consideration for the learner's readiness, learning pace and learning style have rarely been considered. Rather, it is expected that the student will adjust to the pace and methods of the classroom teacher. If the student cannot keep pace or finds the teacher's methods difficult to learn by, he fails. Perhaps this is the most serious shortcoming of traditional education.

Does the traditional approach meet the needs of society and more specifically, the demands of the occupations for which we train? The project directors have asked this question of instructors and administrators alike. As anticipated, there was little objective evidence to support the content of the instructional program.

Consequently, there is doubt as to the effectiveness of the traditional approach to identifying and meeting needs.

Also, this study questions the practice of qualifying students for job entry upon being exposed to selected content for a duration of one or two years. To our knowledge there is no evidence to support the proposition that a time exposure guarantees commpetency.

A critique of tradition is unwarranted unless an alternative is proposed. The project directors believe that the proposal presented in this study is more than competitive with the traditional approach. It is entitled "The Closed Loop Systems Approach to Instruction". It is objective rather than subjective. It strives to avoid vagueness in instructional intents. It is performance based rather than time based. Student competencies are identified, acquired, and assessed. Task surveys are conducted to assure a curriculum relevant to society's needs. Multi-sensory self-instructional experiences allow for individual differences. Feedback is employed to assure continued relevance. Classroom experiences are learner centered rather than teacher centered.

The first application of this instructional design was to the Electronics Technology. It was applied in three phases. Phase one included a task survey instrument, a task analysis of electronics occupations in selected Upper Mid-West cities, and behaviorally-stated student performance objectives for course 605-100 Basic Instrumentation and 605-102 Circuits I. Tasks were identified by both on the job observations and by mailed questionnaires.

Phase two involved the course methodology and performance test for behavioral objectives in 605-100 Basic Instrumentation. Selected learning experiences were presented which lead the learner to the accomplishment of stated objectives. An end-of-the-course performance test has been designed to test for the accomplishment of the objective.

Phase three was to include the course methodology and performance test for behavioral objectives in 605-102 Circuits I. However, due to Dr. Mager's recommendations on phase two, a self-instructional package was substituted in lieu of the original objective. Project participants are certain that the substitute will yield greater returns. Dr. Mager was consulted on each phase of the study.

This project was designed to have wide generalizability of results. It should be of interest to vocational educators nationwide.

Support for any new system in education is desirable. Support for the basic elements of "The Closed Loop Systems Approach to Instruction" has come from the works of professional vocational educators outside as well as from within our system. The proposed method is an assimilation of concepts expressed in the following publications with emphasis on the works of Dr. Robert F. Mager.

1. American Association of Junior Colleges (ERIC) - Multi-Media Instructional Programs.
2. Benjamin Bloom - A Taxonomy of Educational Objectives, Handbook #1 - Cognitive Domain.
3. Benjamin Bloom - A Taxonomy of Educational Objectives, Handbook #2 - Affective Domain.
4. Arthur M. Cohen - AAJC, Developing Learning Specialists.
5. David Cram - Explaining "Teaching Machines" and Programmed Learning.
6. James E. Espich and Bill Williams - Developing Programmed Instructional Materials.
7. E. F. Lindquist - Educational Measurement.
8. Robert F. Mager - Preparing Instructional Objectives.
9. Robert F. Mager and Kenneth M. Beach, Jr. - Developing Vocational Instruction.
10. Oregon State University and U. S. Office of Education - Guide for Vocational Education Curriculum Development.
11. James Popham - The Teacher Empiricist.
12. H. Y. Remmers, N. O. Gage, and J. Francis Rummel - A Practical Introduction to Measurement and Evaluation.
13. John E. Tirrell - AAJC, Independent Study at Oakland.

Definition of Terms

Behavior: refers to any visible activity displayed by the learner.

Behavioral Change : any visible change in the student's knowledge, skill, or attitudes.

Terminal Behavior: refers to the behavior you would like your students to be able to demonstrate at the time your influence over him ends.

Closed Looped: definite feedback channels established for providing corrective action and upgrading to any objective.

Educational Objective: goals which give direction to the student and educational personnel.

Multi-Media: combining various forms of media (audio-visual materials and devices) in designing instructional sequences which assist the student in accomplishing course objectives - a multi-sensory approach to instruction.

Traditional Teacher Centered Instruction: Instruction is provided and administered on a most economical basis. The instructor is the focal point in the classroom. He is the most active member. He sets the pace for instruction. The instructor has approximately 18 hours of class with 5 hours designated for student conferences. There are approximately 25 students per class. A self contained instructor in a self contained classroom.

Learner Centered Approach to Instruction: Instruction is provided and administered on the basis of that which is best for the learner. The learner is the focal point. All materials, facilities, and educational personnel have as their prime goal to assist the learner in the best possible way in accomplishing his short and long range objectives. Instruction is provided at the convenience of the learner and at a pace best suited for him. All efforts are geared to learner success. When the learner does not succeed, corrective action is initiated until success is realized. The instructor is involved with less group instruction and more individualized instruction than in the traditional manner.

THE PROBLEM

The problem simply stated is this: How can the Waukesha County Technical Institute and its Center Schools utilize new instructional innovations to provide an efficient high quality education which meets the needs of the individual and the society in District #8. This problem is, in part, our commitment.

In resolving this problem, it is evident that the needs of the individual and the community must first be identified. We must pinpoint them precisely. Educational programs offered to meet the needs of our District must be based on objective evidence. Occupational and community surveys must be conducted.

The needs of the individual are primary. We are committed to training the learner in areas of employment that suit his interests and abilities. If these areas of employment do not exist in the District, this is unfortunate as the young people will move out. Thus the needs of the local society are secondary to the needs of the learner. However, the needs of industry and other segments of society will be included in the development of instructional programs.

The second phase of the problem is to insure that our programs are efficient, interesting, convenient and of high quality. The term "efficient", as used here, involves both time and money. An efficient program does not waste the learner's nor the instructor's time; it makes the most of each session. An efficient program gives more quality education for the dollar.

The term "interesting" used above implies that the educational process need not be boring. Perhaps that which is needed most in education today are learning experiences which are motivational and enjoyable while maintaining academic excellence. Community colleges which meet this need of the individual will have to fight students away from their doors.

Programs which are offered at an appropriate time, place and pace for the learner are "convenient". Programs should be offered when the learner is available to attend and at a pace that is best for him. This implies that any program should be available almost twenty-four hours per day on an individualized basis.

Programs of "high quality" meet the needs of the learner and the community. Appropriate experiences are provided for him in the classroom and laboratory. These experiences should be "efficient", "interesting" and "convenient".

All efforts of the Administration and staff are directed toward assisting the learner to accomplish his goals. The needs of the learner are paramount. All other needs are secondary. However, it should not be inferred that the needs of the instructional staff, specialists, counselors and administrators are not important. A high morale is basic in serving the learner. A cooperative, enthusiastic, positive attitude is needed from all professional personnel to provide a high quality education.

Having stated the problem and basic elements of it, what new instructional techniques should be incorporated to meet our District's needs? The Curriculum Department has given much time and research to the problem and consequently, proposes the following system.

METHOD

An educational system is a functional unit serving a purpose. The system proposed herein is closed looped. It is organized to be self-evaluating and self-correcting. The purpose of the system is to carry out educational objectives in the most efficient manner and to constantly upgrade itself toward this end. This instructional technique is entitled "The Closed Loop Systems Approach to Instruction". It is learner centered.

"The Closed Loop Systems Approach to Instruction" has three basic components:

1. A behaviorally stated student performance objective.
2. The best means to carry out the objective.
3. Evaluation and upgrading.

A program is built on a series of these closed loops.

The behaviorally stated student performance objective is perhaps the most important component in the system. The objective states the terminal behavior of the student as the instructional goal. It must specify precisely the behavioral change to be exhibited by the learner, the conditions under which this change will take place, and the minimum level of skill development as a result of instruction. The accuracy to which this objective is specified will largely determine the quality of the system. Both instructor (plus backup personnel) and instructee (student) must be committed to accomplishing the objective.

The means by which we carry out the objective is also very important in providing an efficient high quality education. The means can be any educational device or procedure which is totally planned to teach the objective. It too must be closed looped to upgrade itself. The devices or procedures employed should allow the student to proceed at a rate that is convenient for him and it should be available most any time, on an individual or group basis. Multi-media systems calling for responses from the learner in proceeding toward the objective appear most promising. With the use of systems in instruction, it is vital that master teachers be available to provide consultation, motivation and counseling.

The instructor is the key to the success of this plan. He must provide the leadership, motivation and enthusiasm necessary to promote maximum student effort. He must manage the learning environment. He must develop reliable and valid performance tests.

The third component of the closed loop system is evaluation and upgrading. Evaluation is performed to determine the degree of success learners have in accomplishing the objective. If the learner cannot perform as specified by the objective, the system is likely to be at fault. We are assuming that the student has the desire to learn. If the learner cannot perform, corrective action is initiated through the closed loops. As the system is tested by the performance of each student and corrective action employed, a point should be reached where further improvement is no longer practical. When all of the closed looped objectives of a program reach this level of sophistication, we can "guarantee" an efficient high quality education.

It is implied in this instructional systems approach that no one instructional technique can do all things well. For this reason, it is important that we remain flexible. Rigid scheduling and rigid walls may limit the use of the best means to carry out our educational objectives. We should be prepared to deal with changes in methodology and incorporate those changes which improve the quality of our offerings. The Curriculum Department in cooperating with Research and Development is committed to seeking and testing new instructional techniques for upgrading our instructional techniques for upgrading our instructional efforts.

The following section of this report presents three phases of implementation of this plan. Specific objectives are stated which will lead to "process" and "product" accountability; a desirable product of the systems approach.

Objectives

To develop procedures which will yield data that is valid and reliable for making decisions about the effectiveness of our instructional processes and to provide direction for making changes in the curriculum. Such data is a necessary prerequisite to evaluating the effectiveness of the various instructional systems to be introduced at the Waukesha County Technical Institute. This general objective is a composite of the following specific objectives.

I. The Preparation Phase

- A. To identify the target population for the program or course, that is, to identify the personal characteristics of the student.
- B. To identify the skills and knowledge that the employee must exhibit to perform successfully on the job.
- C. To develop program and course objectives that are behaviorally stated and specify the minimum level of student performance.

II. The Development Phase

- A. To establish program and course prerequisities.
- B. To develop pre-tests for the program and course.
- C. To break the instructional program down into courses, units, and learning steps.
- D. To sequence instructional units.
- E. To identify the course content.
- F. To select appropriate instructional materials and procedures.
- G. To develop lesson plans.
- H. To put the course into practice on a trial basis.

III. The Improvement Phase

- A. To check to see how well the instruction meets the objectives.

B. To check to see how well the objectives continue to meet the job.

C. To make changes in the course as required and then make another tryout.

Curriculum Development Procedures to Accomplish Objectives

I. The Preparation Phase

A. Objective: To identify the target population for the program or course; that is, to identify the personal characteristics of the student.

Course of Action: That Student Services in cooperation with the Curriculum Department, division chairman, and department head construct a test battery which will identify the following student characteristics:

1. All previous educational experiences.
2. The skills which the student already possesses upon entering the course or program.
3. Pertinent physical characteristics.
4. Personality, interests, and attitudes when appropriate.

B. Objective: To identify the skills and knowledge that the employee must exhibit to perform successfully on the job.

Course of Action: That Research and Development in cooperation with the Curriculum Department, division chairman, department head, and instructor construct a survey instrument which will identify the tasks of the occupation for which the program or course is being offered.

1. To list all tasks as they really exist.
2. To identify the frequency to which these tasks are performed on the job.
3. To identify the importance of each task.
4. To make a judgement of the learning difficulty of each task.
5. To identify the steps in performing each task.

C. Objective: To develop behaviorally stated student performance objectives from the task listing.

Course of Action: That the Curriculum Department in cooperation with the division chairman, department head, and instructor develop course objectives which specify:

1. Exactly what the learner will be able to do as a result of instruction.
2. The minimum level of student performance.
3. The conditions under which the learner must perform.

D. Objective: To establish program and course prerequisites.

Course of Action: That Student Services, the Curriculum Department, division chairman, department head and instructor cooperatively develop program and course prerequisites upon which to advise the student.

E. Objective: To develop program and course pre-tests.

Course of Action: That Student Services, Research and Development, the Curriculum Department, division chairman, department head, and instructor establish pre-tests which will be effective predictors of student success in the program of his choice and to develop course pre-tests which will identify the skills of the student upon entering the course and to recommend advanced standing should the student exhibit a passing score on the course pre-test.

II. The Development Phase

A. Objective: To break the instructional program down into courses, units, and learning steps.

Course Action: That the Curriculum Department in cooperation with the department head, and instructor will break down the program and establish a timing plan.

1.	Program	1-2 years
2.	Course	1 semester
3.	Unit	1-2 weeks
4.	Learning step	1 hour or less

B. Objective: To sequence instructional units.

Course of Action: That the Curriculum Department in cooperation with the department head and instructor sequence instructional units:

1. From general to specific.
2. By interest sequencing.
3. By logical sequencing.
4. By skill sequencing.
5. By frequency sequencing or
6. By total job practice.

C. Objective: To identify the course content.

Course of Action: That the department head and instructor cooperatively select the course content which when taught will produce the desired behavioral changes.

D. Objective: To select appropriate instructional materials and procedures.

Course of Action: That the Media Specialist, Curriculum Coordinator, librarian, department head, and instructor cooperatively select the appropriate instructional procedures which will assist the instructor in accomplishing the course objectives with the learner. They will:

1. Choose the technique that most closely approximates the performance conditions called for by the course objectives.
2. Choose the technique that causes the student to perform in a manner most closely approximating the performance called for on the job.
3. Choose the technique that will allow the student to make the largest number of relevant responses per unit time.

E. Objective: To develop lesson plans.

Course of Action: That the Curriculum Coordinator will assist the instructor for the purpose of:

1. Outlining the learning units.
2. Putting into sequence the tasks and objectives to be taught.
3. Identifying the type of student performance associated with each step of the tasks to be learned.
4. Identifying the content on the basis of the tasks to be taught. Additional content of the "nice to know variety" may be added last if time permits.
5. Identifying instructional procedures appropriate to the student performance required and list available materials and devices.
6. Making minor adjustments to assure continuity from one lesson plan to the next.

III. The Improvement Phase

A. Objective: To check to see how well the instruction meets the objective.

Course of Action: That Research and Development and the Curriculum Department will assist the instructor in developing performance tests which test for the course objectives. These tests should be checked for reliability and validity.

B. Objective: To check to see how well the objectives continue to meet the job.

Course of Action: The program coordinator will continually feedback information to the division chairman, department head, and instructor for the purpose of continually updating the course objectives to meet the job.

C. Objective: To continue to make changes in the program or course as required.

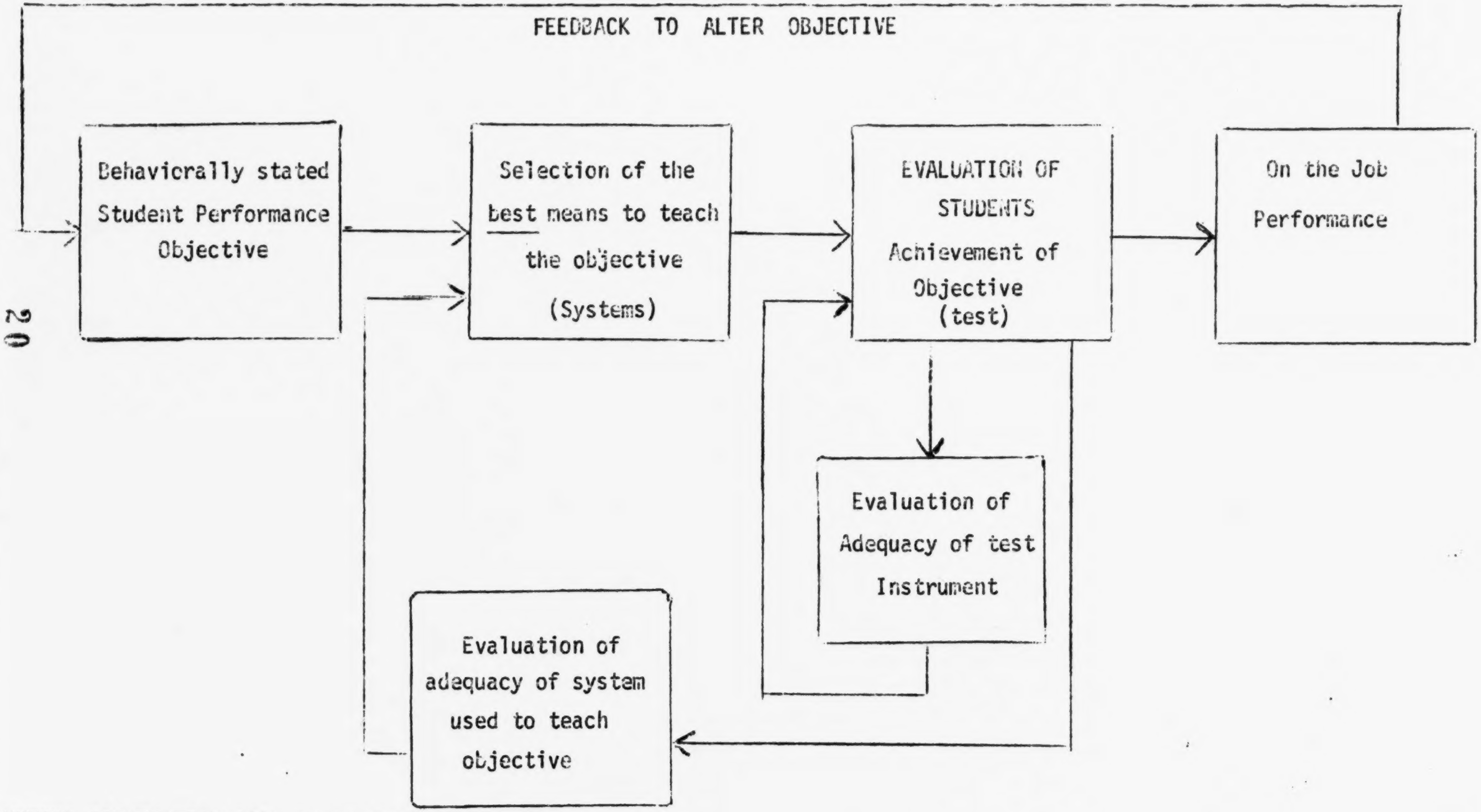
Course of Action: All previously identified personnel will, when appropriate, assist the instructor in making changes in the course as required.

The objectives outlined to this point are inclusive for the "systems approach" as a total concept. In this project objectives A, B, and C of Phase I, The Preparation Phase, and objectives A, C, D, and E of Phase II, The Development Phase, have been successfully accomplished. In addition inroads have been made into objective F, II. Data and materials relating to the accomplishment of these objectives are contained in the remainder of this report.

In order to accomplish the stated objectives in "The Preparation Phase" and generate an appropriate data base for the "The Developmental Phase" a multi-purpose, objective response survey instrument was developed. While the instrument, itself, is relatively voluminous; the mechanism for response is relatively simple.

The instrument and accompanying cover letter may be examined in their original form in Volume II of this report.

THE CLOSED LOOP SYSTEMS APPROACH TO INSTRUCTION


FEEDBACK TO ALTER OBJECTIVE
Behaviorally stated Student Performance Objective
Selection of the best means to teach the objective (Systems)
EVALUATION OF STUDENTS Achievement of Objective (test)
On the Job Performance
Evaluation of Adequacy of test Instrument
Evaluation of adequacy of system used to teach objective

RESULTS

"Task Analysis" instruments were mailed to 287 selected industries in the Milwaukee, Chicago, and Minneapolis-St. Paul areas. The Milwaukee area industries were selected from the telephone directory. Companies were chosen for their electronics manufacturing, servicing and design characteristics. In addition the selection was reviewed to insure that the sample consisted of a cross section of both large and small companies.

Chicago area firms were selected from a directory titled "Metropolitan Chicago Major Employers". Minneapolis-St. Paul area firms were selected from a directory titled "Minnesota's Electronics and Related Science Industries". When selecting firms for all areas the criteria used was based upon known electronics characteristics and number of employees.

Though the survey sample was not randomly selected the investigators believe the sample to be representative of the type of firm employing graduates from two year post high school vocational-technical institutions of higher education.

As a means of verifying the validity of the results received on the mailed questionnaires seven random, on-the-job, samples were taken in the Milwaukee area. A member of the WCTI Electronics Department Staff personally interviewed and recorded the responses of the sample.

A summary of all employer contacts is as follows:

Table #1
Summary of Contacts and Returns

Area	Method of Contact	No. Contacted	No. Returned	% Return
Chicago	mail	96	32	33.3%
Milwaukee	mail	93	25	26.9%
Milwaukee	personal interview	7	7	100.0%
Minneapolis	mail	98	29	29.6%
	Totals	294	93	31.6%

The overall percent of instrument return (31.6%) cannot be considered as a good return. This poor return may be attributed to three factors: (1) the length of the questionnaire; (2) superficial appearance of questionnaire complexity; and (3) respondent resistance to impersonal contact. However, the project directors are convinced the sample is a representative sample and therefore utilize the data with confidence.

Data comparisons were made between "metropolitan areas", "personal interview and mailed returns", and a category designated as "designs and not designs". The data comparisons made between "metropolitan areas" revealed no apparent significant difference in technician training or in technician tasks and activities.

When comparing "mailed" responses to those collected during a "personal interview" the following difference was noted. Respondents contacted personally generally had more training than respondents contacted through the mail. Fifty-seven percent indicated two years of college level technical training (A.A.S.) and forty-three percent indicated two years of college level technical training plus experience in the "personal" contact group compared with 19% and 16% for the respective categories in the "mail" contact group. The "personal interview" group was based on a relatively small sample (N = 7) when compared to the "mailed returns" (N = 86). A comparison of task analysis data for the previous two categories as well as "tool" and "equipment" data comparisons produced several variations in the "frequency of performance" category in the "task analysis" section. Generally the differences noted in the "task analysis" section referred to a frequency differential in "daily" vs. "occasionally". It should be noted that the "personal interview" group indicated considerably fewer items in the "equipment" sections than did the "mailed return" group. However, in the "tool" and "physical characteristics" sections the responses were much the same. With the "personal interview" group performing the tasks included in items 11, 12, 16, 20, 21, 22, 25, 27 and 30 less frequently than the "mailed returns" group. While on items 3, 8, 26, 28 and 32 more frequently than the "mailed return" group.

The third and last category refers to the nature of the activity technicians were reported to perform. Electronic technicians engaged in design activities are generally considered, by many, to be more sophisticated and therefore somehow unique. The differences observed (see tables 3 and 4) between "designs" and "not designs" was predictable in that the variance is inherent in the question itself. That is to say questions and statements containing direct reference to "design" functions will undoubtedly result in differences on those specific questions and statements when comparisons are made with other groups on the same questions.

Even though differences were found to exist relative to the "designs" and "not designs" sections of the questionnaire other functions and activities remained very much the same throughout the rest of the questionnaire (see tables 3 and 4). Two exceptions were observed: The first being a question referring to the "making of mechanical adjustments". The "design" group reported making such adjustment only occasionally (52%) while the "not designs" group reported making mechanical adjustments daily (47%); the second being a question referring to the "Performance of tests on electrical and electronic systems". The "designs" group reported an occasional "performance" (61%) and "not designs" group reported a daily "performance" (62%).

The purpose of analyzing the returns in these two categories was to determine if differences, which were expected for certain sections of the "designs" and "not designs" categories, also occur in other functions and activities performed by technicians. Stated in question form: Is the design activity the only activity reflecting performance differences? The answer would be affirmative, as the remaining functions and activities remained basically similar in terms of frequency of performance and percent of respondents performing at that frequency.

Data Tables

Due to the unusual amount and complexity of the data collected in this study this report has been divided into two volumes. Please refer to Volume II for the recorded data.

The next three parts of this section contain "Consultive Packages" as mailed to Dr. Robert F. Mager, for his comments and suggestions. His unedited replies have been included with each package.

FIRST CONSULTIVE PACKAGE

July 16, 1969

Dr. Robert F. Mager
13245 Rhoda Drive
Los Altos Hills, California 94022

Dear Doctor Mager:

Enclosed you will find a block diagram of our systems approach to instruction. This system involves three major areas of curriculum development: (1) behaviorally stated student performance objectives, (2) instructional procedures incorporating multi-media systems, and (3) student performance evaluation. We desire that you give one day ($200) to evaluating each major area.

For part one of this feasibility study, we ask that you evaluate and make recommendations on the task survey instrument and the behaviorally stated student performance objectives for the first two courses in the Electronics Engineering Technology, 605-100 Basic Instrumentation and 605-102 Circuits I. This will be the extent of the materials for the first major area.

More specifically, please evaluate and make recommendations on:

1. The ability of the task survey instrument to identify tasks. Your over-all impression of the instrument (pro and con) is sufficient.

2. The clarity of the behaviorally stated student performance objectives for courses 605-100 Basic Instrumentation and 605-102 Circuits I. The evaluation criteria from your writings include:

    A. Terminal behavior
    B. Minimum level of performance
    C. Performance conditions

Enclosed is a $200.00 check for your consulting fee. We will forward additional materials on major areas two and three and appropriate fees as this study unfolds.

Sincerely,

George A. McGuire
Curriculum Coordinator

GAM:vb
Enclosures

SURVEY INSTRUMENT

The format and content of the survey instrument and cover letter may be examined in Volume II pages 1 through 18.

WAUKESHA COUNTY TECHNICAL INSTITUTE

BASIC INSTRUMENTATION

605-100

One Semester 2 Credit Hours

Description

A beginning laboratory course that concentrates on identifying and connecting electronic parts, instruments and circuits. Students will examine and electrically operate all types of electronics parts; they will construct circuits from schematic diagrams; and they will connect and use many different electronic test instruments to make precision measurements.

Course Objectives

Within a period of five minutes, the student will be able to complete any one of the following 14 tasks without error.

1. Identify all 18 of the electronic parts listed below:
   a. resistor types: fixed and variable
   b. capacitor types: mica, ceramic, paper, variable, and electrolytic
   c. transformer types: power, audio and radio frequency
   d. choke types: filter and radio frequency
   e. devices: solid state diode, transistor, vacuum tube, gas tube, silicon controlled rectifier and integrated circuit

2. Use the color code to determine the rated electrical size and tolerance of:
   a. five different resistors
   b. five different capacitors

3. Construct a circuit using a tube or transistor and at least four components from a schematic diagram.

4. Use a volt-ohm-meter on one range of each of its functions to make measurements of:
   a. DC volts
   b. AC volts
   c. DC amperes, milliamperes or microamperes
   d. Ohms

5. Use a vacuum tube voltmeter on one range of each of its functions to make measurements of:
   a. DC volts
   b. AC volts
   c. Decibels
   d. Ohms

6. Use the oscilloscope pattern of a sine wave to measure its:
    a. amplitude
    b. frequency

7. Connect an oscilloscope to an audio frequency oscillator and adjust the oscillator to obtain an output at a specified frequency and amplitude.

8. Adjust a radio frequency signal generator to a specific frequency and verify the setting by measuring the output with a radio receiver or other frequency sensitive device.

9. Use a Wheatstone bridge to measure the electrical size of an unknown resistor.

10. Use an impedance bridge to measure the electrical size of an unknown inductor or capacitor.

11. Use a wattmeter to measure the power used by an operating circuit or device.

12. Use a potentiometer and standard cell to precisely measure an unknown voltage.

13. Use an electronic counter to measure an unknown frequency.

14. Connect a chart recorder to measure and record a changing DC voltage.

WAUKESHA COUNTY TECHNICAL INSTITUTE

CIRCUITS I

605-102

One Semester 6 Credit Hours

Description

This first course in electronics concentrates on the behavior of resistive circuits connected to either direct or alternating voltage sources. Training begins with the introduction of the physics of electricity along with units, definitions and symbols for electrical quantities. The major portion of the course is a study of series circuits, parallel circuits, series-parallel circuits, network theorems, and magnetism.

Course Objectives

By the completion of the course students will be able to:

1. Apply the basic electrical properties of voltage, current, power and resistance to the analysis of electronic circuit problems.
2. Design and construct voltage dividers, current dividers, bridge networks, volt-ohm meters, and other series-parallel resistive networks connected to one or two generators.
3. Determine the voltage, current, resistance and power characteristics of any of the resistive circuits listed in objective #2, through mathematical analysis.
4. Describe, and mathematically compute, the magnetic flux density, magnetomotive force and permeability of a ferromagnetic series circuit.
5. Describe the magnetic action through which motors convert electrical power to mechanical, and generators convert mechanical power to electrical.
6. Compute and measure the effective, average, peak and instantaneous voltage of a given sine wave.

Unit Objectives

The unit objectives listed for this course represent minimum goals and students are expected to achieve 100% mastery.

PRE-REQUISITE OBJECTIVES

Most of the behavioral objectives in this group are considered prerequisite to those included with the units. It will be necessary for the student to complete a large part of each of these before attempting the unit objectives, but complete mastery is not expected until the two sets of objectives are integrated.

1. From a pictorial diagram of the Bohr concept of a copper or aluminum atom, the student will be able to:
   a. show where the basic electrical force originates
   b. point out the different electron shells and subshells
   c. show how many electrons are contained in each shell and subshell
   d. distinguish between the highest and lowest electron energy levels
   e. point out the valence band and valence electrons
   f. show what action would make the atom become a positive or negative ion
   g. describe the electron action that would cause the atom to radiate energy
   h. name three sources of energy that could ionize the atom

2. The student will be able to draw a schematic diagram of a complete electrical circuit showing a generator, a load, and connecting wires. By adding to or deleting connections, the student will illustrate the circuits listed below, one at a time, and then describe how each affects the generator and the load.
   a. a short circuit
   b. an open circuit
   c. an electrical ground

3. The student will be able to describe in writing:
   a. the concept of electrical current
   b. the concept of electro-motive force
   c. three atomic factors that contribute to the concept of electrical resistance
   d. the concept of conductance
   e. the concepts of voltage rise and voltage drop

4. The student will be able to define in words and by mathematical equation:
   a. the coulomb
   b. the ampere
   c. the volt
   d. the foot-pound
   e. the joule
   f. the watt
   g. the horsepower
   h. the kilowatt-hour

5. From a pictorial diagram showing the internal construction of a cell in a battery, the student will be able to:
   a. point out the positive and negative electrodes
   b. show the location of the electrolyte
   c. show the surface area where polarization may take place
   d. write a word description of the chemical action that makes one electrode positive and the other negative
   e. write a word description of the term "internal resistance"

6. Given an electrical circuit with a variable source of voltage connected to a variable load resistance, the student will be able to write a word description of:
   a. how the circuit current will vary with changes in the source voltage when the load resistance is held constant
   b. how the circuit current will vary with changes in the load resistance when the source voltage is held constant
   c. how the unit of resistance measurement is derived from the ratio of applied voltage to circuit current

7. The student will be able to:
   a. describe the relationship between the horsepower and the watt
   b. define the efficiency of a circuit or device
   c. define the term "specific resistance" as applied to wire computations
   d. define the term "temperature coefficient of resistance" as applied to wire computations
   e. explain the meaning of all columns of figures used in the American Wire Gauge Table
   f. describe the relationship between different American Wire gauge numbers
   g. describe the effect on circuit current when the generator supplies a DC voltage as compared to when it supplies an AC voltage

Unit 1. BASIC CIRCUITS

Within the limits of slide rule accuracy (1%) and/or the normal tolerance of electronic test instruments (3%), students will be able to:

1. Compute the voltage, current, resistance and power for a circuit consisting of a generator connected across a load when any two of the factors are given or measured.
2. Distinguish between series and parallel connections of components on a schematic circuit diagram.
3. Measure the internal resistance of a generator.
4. Compute the total resistance and current, the individual voltage drops, and the individual power dissipations of a generator load consisting of three resistors in series. The student also will be able to construct this circuit and measure the same values.
5. Design an unloaded voltage divider to provide two specified voltage outputs.
6. Compute the total resistance and voltage, the individual branch currents, and the individual power dissipations of a generator load consisting of three resistors in parallel. The student also will be able to construct this circuit and measure the same values.
7. Design a current divider to produce two specified branch currents.
8. Compute the efficiency of a device when the input and output powers are known.
9. Given the temperature coefficient of resistance of a specific material, determine the temperature at which the resistance of the material apparently becomes zero ohms.
10. Compute the resistance of a given length of wire when the cross-sectional area, specific resistance and operating temperature are known.
11. Compute the electrical input and output power for a DC motor when its rated voltage, horsepower and efficiency are known.

Unit 2. COMPLEX RESISTIVE CIRCUITS

1. Students will be able to design a voltage divider capable of providing specified voltages and currents simultaneously for two different loads. The output voltage, internal resistance and power capability of the source are known.

2. Given the source voltage and all resistance values for a circuit comprised of two generators connected in parallel across a load, students will be able to compute:

    a. the magnitude and direction of the generator and load currents by writing and solving Kirchoff's Law equations.
    b. the magnitude and direction of the generator and load currents through the application of the superposition theorem.
    c. the magnitude and polarity of the load voltage through the application of Thevenin's theorem.
    d. the magnitude and direction of the load current through the application of Norton's theorem.
    e. the load resistance value that will dissipate the maximum possible power.

3. Given the source voltage and all resistance values of a Wheatstone bridge circuit, students will be able to compute the magnitude and direction of the current through each part of the bridge by the application of the Delta-Wye transformation procedure.

Unit 3. METERS AND MEASUREMENT

1. Given a source voltage and two variable resisters, students will be able to measure the resistance of a direct current meter movement.

2. Using a direct current meter movement of a specified sensitivity and resistance, students will be able to:

   a. design a voltmeter having three different voltage ranges. Each range will be separated from the other by a factor of 10.
   b. design a three range milliameter with an Ayrton shunt. Each range will be separated from the others by a factor of 10.
   c. design a three range ohmmeter that includes a zero adjustment. Each range will be separated from the others by a factor of 10.

3. Given a 1000 ohm per volt voltmeter, the student will create a mathematical example to show how the voltage reading on the meter can be erroneous due to the loading effect.

Unit 4. MAGNETISM

1. Given a pictorial drawing of a bar magnet with the north and south poles marked, the student will be able to:
   a. draw six complete magnetic lines of force on the picture
   b. write at least three rules governing the magnetic lines of force
   c. state the magnetic principle that causes a small iron nail to jump on a magnet when the two are brought together
   d. state the magnetic principle that causes a compass needle to move when held closely to one pole of a bar magnet

2. Given a pictorial drawing of a coil of wire wound over a straight core on which the direction of the winding and the direction of current through the winding are labeled, the student will be able to:
   a. mark the north and south poles on the drawing
   b. draw six complete magnetic lines of force on the picture and indicate their direction

3. The student will be able to describe the properties of:
   a. magnetic flux
   b. magnetomotive force
   c. reluctance and reluctivity
   d. permeance and permeability
   e. flux density (B)
   f. magnetic intensity (H)

4. Given a BH graph for a ferromagnetic material, the student will be able to:
   a. state why BH graphs are needed for computations with ferromagnetic materials but are not required when working with nonmagnetic materials
   b. point out the saturation knee on the graph
   c. describe the action of the magnetic domains in the material as the value of H is increased from zero to a point beyond the saturation knee
   d. compute the normal, incremental, differential, and average permeability of the material for any specified point on the graph

5. Given the hysteresis graph of a ferromagnetic material, the student will be able to:
   a. describe how the action of magnetic domains produces residual magnetism
   b. state why the hysteresis effects is considered an energy loss

6. Given the number of turns on a toroid coil, the dimensions of the nonmagnetic core on which it is wound, and the current through the winding, the student will be able to compute:
   a. the reluctance of the magnetic circuit
   b. the magnetomotive force generated
   c. the total magnetic flux

7. Given the number of turns of a coil wound on a rectangular transformer type ferromagnetic core, the dimensions of the core, a BH graph of the core material, and the current through the coil, the student will be able to compute:
   a. the flux density (B) of the magnetic circuit
   b. the magnetic intensity (H)
   c. the permeability of the core material

8. Given a small air gap in a ferromagnetic circuit of a specified flux and cross-sectional area, the student will be able to:
   a. state the reason fringing occurs around an air gap
   b. compute the magnetomotive force required to maintain the flux through the air gap

9. Given all the constants of a horseshoe electromagnetic circuit, complete with a ferromagnetic bar across the poles, the student will be able to compute the force necessary to pull the bar away from the magnet.

10. From a pictorial drawing of the poles of a permanent horseshoe type magnet, between which is a cross-secional view of a one turn electromagnet, the student will be able to describe the magnetic action that causes the electro-magnet wire to turn. The poles of the horseshoe magnet are marked north and south and the direction of current through the wire is given.

11. Given a direct current motor with the armature and field windings connected in parallel, the student will be able to:
    a. describe in words and by mathematical equation the factors that determine the:
       (1) armature torque
       (2) counter electromotive force
       (3) speed of rotation
    b. draw a schematic diagram of the motor circuit showing an appropriate speed control
    c. draw a picture showing the construction of the commutator
    d. describe the magnetic action that makes a commutator essential to the operation of the motor

12. Given a direct current motor with the armature and field windings connected in series, the student will be able to describe the magnetic action that governs the speed of rotation.

13. Given a direct current generator with the armature connected to solid slip rings, the student will be able to:
    a. describe the magnetic action that causes an electro-motive force to appear across the slip rings.
    b. determine the polarity of the electro-motive force when the direction of the magnetic field and the direction of motion are given
    c. draw a picture of the amplitude of the generated electro-motive force versus the angle of rotation
    d. name three internal factors that determine the instantaneous amplitude of the electro-motive force

14. From a graph of one sine wave cycle whose amplitude and time are given, the student will be able to compute:
    a. the instantaneous voltage at any time
    b. the frequency
    c. the time of one alternation; one period
    d. the peak to peak voltage
    e. the average voltage of one alternation; one cycle
    f. the effective or RMS voltage

July 29, 1969

Mr. George A. McGuire
Curriculum Coordinator
Waukesha County Technical Institute
222 Maple Avenue
Waukesha, Wisconsin 53186

Dear Mr. McGuire:

Someone has done a whale of a lot of work--and it shows. These are probably the best stated objectives I have seen since reviewing electronic objectives for the Air Force. There really aren't many suggestions I can make regarding clarity, and I am pleased to be able to say so.

The fact you are planning to use a task survey instrument is also encouraging, and I hope you will be as willing to use the results as you are to work at being clear about intents. It isn't easy to modify a traditional course on the basis of task analysis information, but the rewards can be great for doing so.

I have only one comment on the use of objectives worth making at this point. *Using* objectives means accepting each and every student who achieves your criteria, even if he never paid attention in class or never appeared interested. It also means rejecting each and every student who does *not* meet your specified criterion, for whatever reason he failed to meet that criteria. When you run into borderline cases think about changing your minimal criterion for all students rather than bending the criterion for a single student. When you bend, the criterion becomes worthless.

Again let me congratulate you on a fine job. Tell me whether I may be allowed to show these objectives to others.

Sincerely,

Robert F. Mager

RFM:jm

REVIEW COMMENTS

July 29, 1969

Questionnaire

1. If the little slip of white paper with the three sentences on it are all you intend in the way of instructions, you may be disappointed with the results. Questionnaires flood industry people by the dozens, and they tend to go from in-basket to waste-basket. The attitude is that if "they" aren't interested enough in what they are doing to take the time to come around and gather the information in person, then I'm not either. Let me suggest two things. First, expand the cover sheet (or add a cover letter) that describes the purpose and the importance of the project--and eliminate the suggestion that the exercise should not exceed 15 minutes. Say it will take only a short time, but do not put a time limit on it. Second, give the questionnaire in person to those you wish to fill them out and explain any questions they might have. If that is not practical, at least call on the phone to indicate your interest in accurate information, and to let people know you are imposing on their time.

2. Under BASIC INFORMATION, modify to "Please check the academic requirements..." The word training there somehow implies skills.

3. Under TASK ANALYSIS the three levels of importance are listed as essential, routine, and trivial. This is like being asked, "How many tasks do you ask people to perform that are trivial?" and this is likely to be taken as an insult, so I suggest you use other terms. Perhaps something like Very Important, Average Importance, and Low Importance.

4. Frequency of Performance might be modified to read Frequently (daily or oftener), Occasionally, Rarely.

5. Items 35 through 47 of TASKS PERFORMED BY TECHNICIANS should be deleted. For one thing, the person filling out the questionnaire does not know what a person needs to know in order to perform. He only knows what the traditional academic requirements are and what tradition tells him someone "ought" to know to perform various tasks. For another, it is simply not true that technicians need to know things about the items mentioned to perform satisfactorily. For example, the most highly skilled radar maintenance man I ever tested (on an actual radar system) could barely speak English, had never gone to electronic school, had never heard of Ohm's Law or Thevinin's Theorem. Yet he could put a malfunctioning system back on the air faster than anyone else.

My point is not that technicians should not know matters theoretical, it is that you will not get accurate information by asking untrained persons which mediating concepts are needed for certain skills to be performed.

Since more than one skill will likely be checked it is unlikely you will be able to relate the subjects to the skills anyway.

Instead, find out in as much detail just what tasks are performed, and do your own analysis of what content is needed for those skills to be performed. While it is sometimes useful to ask the person performing a skill (in this case the technician) what he has to know to perform it, it is not useful to ask his supervisor.

6. The ELECTRICAL AND ELECTRONIC EQUIPMENT ANALYSIS is very good and will give you the kind of information you need to analyze your curriculum. I would probably put it first. It can be filled in quickly, and will give the

filler some time to think about the more general categories listed under TASK ANALYSIS.

7. Instead of "Purpose" on the pages labeled INDUSTRIAL, TOOLS AND ELECTRICAL AND ELECTRONIC TEST EQUIPMENT, I suggest you provide a clear instruction about what you want done. Such as "Please check as many of the physical characteristics listed below that are typically made by your technicians in performing their duties."

8. Be sure to have these forms tested by someone you want to fill it out (target population). Sit with him while he completes the forms, and write or record all questions and comments. It is essential to pilot test such forms to get meaningful information from them.

General comments on TASK ANALYSIS

1. The items listed describe categories of tasks rather than tasks. While this is useful information, it will not give you detailed insight as to just what the technician does. For example, adjusting the servo amplifiers of a missile system is quite different task than testing the high voltage on a TV system. Yet both would come under the general heading of Item 21. "Performs tests on electrical and electronic systems." I don't know how important it is to get such detailed information at this time, but you should be aware of the possible ambiguity of the categories.

2. A highly accurate task analysis cannot be performed by mail. Just because a person can perform a skill does not mean he can also perform a task analysis of that skill. People can seldom tell you just what steps they perform, and why. As long as you know the limits of a mail analysis you will

be safe.

General comments on Objectives

1. These objectives are extremely well stated. The learner should have little trouble identifying what will be expected of him.

2. If you have gone to the trouble of being so specific (and you have), and if you have spelled out a minimum acceptable criterion, then you MUST stick to that criterion, and make no exceptions. The first time you let someone by because he "almost" made it your word will be suspect and the students will begin to study you instead of the subject.

3. I would be interested in seeing the criterion items related to each of these objectives so I can assess their relation to the objectives.

4. One matter appears to be highly contradictory. On the one hand you specify the objectives of the course, thereby telling the students exactly what kind of performance on his part will be considered acceptable. On the other hand, you specify the time the students will have to spend studying each aspect of the course. You can have one or the other, but not both. If a student can perform as desired in half the specified time or less, can he take the criterion exam and move on? Or must he hang around for the others to catch up?

If you feel you have no choice at the moment but to make all students move through the course at the same rate, add one or two sentences to the objectives sheets given to the students. Tell students that these are the minimum objectives to be achieved for a given unit and that each achievement will be rewarded with __________; further, additional competence will be rewarded with _______ and calculated by ________. I assume for this comment that you are using a range of grades rather than some form of pass-fail.

5. I have been presumptuous enough to comment on the worth of a few of the objectives. After spending so much time struggling to learn so much electronic theory I never had occasion to use and never saw anyone else use, I find it impossible not to get in my digs. Simply ignore those comments, please.

Objectives - Course 605-100

1. The objectives for this course are extremely good. They describe meaningful skills and should give the student a great deal of guidance in making learning decisions.

2. There are only one of two minor suggestions relating to these objectives. One is that items 4 and 5 might be improved in clarity. What does "read the scales..." mean? Does it mean read the numbers on the scale, or does it mean given a scale with a pointer on it, tell the reading?

3. For item 7 can you specify the types of oscilloscopes and the frequency tolerance that will be allowed?

4. Finally, it might help to specify a tolerance for items 9 through 13. Then there won't be any argument at exam time.

Prerequisite objectives

1. It may seem unimportant to you, but we find it useful to make a distinction between objectives (which describe specific outcomes) and goals (which describe general intents). Therefore, we would refer to your "Course Objectives" as goals because they are general rather than specific. By no means delete them, as goal statements are important for a number of reasons. I just feel it worth reminding you that since general and specific statements are quite different things, they perhaps ought to have different labels.

2. It is excellent that you specify prerequisite objectives. This truly gives the student (and those who teach the previous course) useful clues about what skills will be required. If you specify prerequisite objectives and show these to the student, however, you must be sure to require the behaviors listed...otherwise the student will quickly learn that what you say matters and what in fact matters are quite different. So if you do not intend that these prerequisites really stick, do not show them to the student. Don't tell anyone they exist. And it may be a little difficult to really stick by the prerequisites, since typical prerequisites are little more than empty verbiage and you will be flying in the face of tradition. Fly! Fly!

3. A few comments regarding the objectives themselves, though they are generally very good.

More meaning isn't added to a word by underlining it, and so I would try to describe what you mean by "demonstrate the meaning of" in item #2.

4. I think I could perform all four items listed under item #3 without being given the given. I don't see how the given helps or why it is necessary.

5. #4 is just dandy.

6. Again for #6 I don't see how the given is necessary to complete 6c and 6d. If the given is not needed I would suggest a separate objective.

In 7a and 7f the word "show" causes me to wonder whether you mean for me to write an equation or two, or point something out, or describe.

Objectives - Course 605-102

Unit 1. BASIC CIRCUITS

1. These are also just fine. If you have never had an argument over tolerance or over the "limits of slide rule accuracy," I would leave things as is. If there has been any question at all, however, I would try to be more specific about limits that will be acceptable.

2. Unlike most basic circuits courses I have seen, these objectives describe meaningful and useful skills (with the exception of #10, of course. Some day I hope to meet someone who had genuine occasion to compute the resistance of a wire from the cross-section and temperature.)

Unit 2. COMPLEX RESISTIVE CIRCUITS

3. Other than a question about spending five weeks to learn this material,

the objectives are well written. (Oops. I forgot that the student probably has other things to do during that time.)

Unit 3. METERS AND MEASUREMENT

4. These too are well stated, and #1 and #3 are quite useful.

Unit 4. MAGNETISM

5. Again, these are very well done. Some seem more appropriate to an engineering course, but I shouldn't comment on that.

RFM

SECOND CONSULTIVE PACKAGE

September 25, 1969

Dr. Robert F. Mager
13245 Rhoda Drive
Los Altos Hills, California 94022

Dear Dr. Mager:

Considerable time has passed since our last communication. We have had a delay in development on this project due to our other commitment to the District. Being a small school (850 full-time students) most of us wear several hats in carrying out District responsibilities. Now that the school year is underway, perhaps we can return to a schedule.

We are very much pleased with the recommendations given to "phase one" of this feasibility study. Your comments indeed give us the direction we are seeking. In regard to your request to show these objectives to others, please feel free to do so.

"Phase two" of this study involves the course methodology and the performance test for the objectives of 605-100 Electronics Instrumentation. In addition to these items, we would like to have you comment about our proposed grading system. "Phase three" will include the course methodology and the end of course performance test for the course 605-100 Circuits I.

It is important that we convey to you the present status of our classroom methodology. We are just beginning to scratch the surface in individualizing instruction. We are in the planning stages and have yet to "tool up" for this approach. Consequently, we are a traditional technical institute. We are locked in step. We are using team teaching which gives us a small degree of flexibility in meeting the learner's needs. We are using programmed instruction in some courses, on a group basis. Most instruction consists of the self-contained teacher in the self-contained classroom.

Enclosed is the curriculum development for your evaluation and recommendations. Attached to each item is a slip of paper giving information and directions. A $200.00 check is enclosed for your consulting fee.

Dr. Robert F. Mager
September 25, 1969
Page 2

Again, we are very much pleased with the direction given to "Phase one" of this project, and we are looking forward to your recommendations on "Phase two".

Sincerely,

WAUKESHA COUNTY TECHNICAL INSTITUTE

George McGuire
Curriculum Coordinator

GAM/aj

Enclosures

1. Our proposed grading system.

   We are considering the elimination of our present ABCDEF grading system. Our alternative would be the use of the terms "mastery" and "incomplete" in reference to the accomplishment of each objective. This would be a "go" or "no go" type job task of grading system which places the emphasis on the accomplishment of specific skills rather than the attainment of a letter grade. Reporting of student achievement would consist of a list of objectives mastered. Please give us your reaction to this proposed grading system.

2. Two occupational levels for training technicians.

   In "phase one" of this study we failed to convey to you the type of electronics technican for which this curricular design is intended. We train electronics technicians at two levels; service and engineering. This study is specifically concerned with the Electronics Engineering Technician. A description of the duties performed by each type of technician is given below.

   To repair a television receiver requires considerable knowledge of electronics as well as manipulative skill. However, because repairmen on any type equipment are not required to design electronic circuitry, there is no need to comprehend the subject to this extent. In fact, most repair work reduces to a series of recurring faults and a well established set of trouble shooting routines. Persons with sufficient training to perform repair jobs can be classified as "Electronics Service Technicians."

   Many technicians are employed in jobs that call for an ability to design circuits, conduct original evaluations of products, or innovate trouble shooting techniques on complex or unusual equipment. To perform this work the technician needs a very extensive knowledge of electronics fundamentals that in some areas, overlaps the training offered to electronics engineers. This type of technician is classified as an "Electronic Engineering Technician."

605-100 Electronics Instrumentation

Student Activities

The purpose of this development is to identify the learning experiences provided for the student through our current approach to instruction. It identifies the present status of classroom methodology for this course. It attempts to identify instruction from the learner's point of view.

We are also considering alternative methods of providing the same experiences. Our ultimate objective is to individualize these learning experiences. We would like your comments on this development to date. We would appreciate your comments on a means by which the transition from traditional instruction to individualized instruction can be most readily achieved. Also, we are seeking direction on different modes of individualizing learning experiences by other than programmed textbooks. We can produce many forms of media locally.

WAUKESHA COUNTY TECHNICAL INSTITUTE

ELECTRONICS INSTRUMENTATION

605-100

Student Activities

Each of the sixteen three-period laboratory meetings is preceded by a one period class where explanations, directions and questions can be discussed. The detailed outline that follows is a suggested guide of the minimum activities required for meeting the objectives of the course.

Week 1

DISCUSSION PERIOD. Students will:

1. Listen to a presentation of general laboratory rules and procedures.
2. Watch a demonstration of how to interpret the position of the pointer on a volt-ohm-meter in terms of DC volts and milliamperes.
3. Watch a demonstration of how to connect and operate a DC power supply in the laboratory.

LABORATORY. Students will:

1. Tour the laboratory to learn the location of parts, wires, test instruments and related equipment.
2. Construct a simple DC circuit using the power supply and a resistor.
3. Operate the above circuit and use the volt-ohm-meter to measure a number of different voltages and currents.

Week 2

DISCUSSION PERIOD. Students will:

1. Listen to a lecture describing the physical construction of fixed and variable resistors. During the lecture samples of each type resistor will be inspected by the students.
2. Listen to a lecture explaining the electronic color code and how it is used to mark resistors.
3. Watch a demonstration of how to interpret the position of the pointer on a vol-ohm-meter in terms of ohms.

LABORATORY. Students will:

1. Translate at least six different color combinations into resistance and tolerance values.
2. Locate at least six different resistance values by their color markings from a large group of resistors.
3. Use the volt-ohm-meter to measure the resistance and verify the color markings on at least six different resistors.

Week 3

DISCUSSION PERIOD. Students will:

1. Watch a display of the correct schematic symbols for fixed and variable resistors, fixed and variable capacitors, solid state diodes, transistors, vacuum tubes, GD tubes, silicon controlled rectifiers and integrated circuits.
2. Inspect sample parts of all the above types. At the same time the students will listen to a lecture correlating the physical connections on the parts with those used on the schematic symbols.
3. Watch a demonstration of how to use a schematic diagram to breadboard component parts into a working circuit.
4. Watch a demonstration of how to verify circuit connections by using the volt-ohm-meter as a continuity checker.

LABORATORY. Students will:

1. Construct a breadboard circuit using a tube, at least three resistors, and a capacitor from a schematic diagram. Connections on the finished circuit will be verified with the volt-ohm-meter used as a continuity checker.
2. Construct a series-parallel resistance network from a schematic diagram. After construction, students will connect the circuit to a DC power supply and make a number of voltage and current measurements.

Week 4

DISCUSSION PERIOD. Students will:

1. Watch a display of the correct schematic symbols for various types of transformers, coils and relays. At the same time samples of each type of part will be inspected by the students.
2. Watch a demonstration of how to trace transformer windings with a continuity check.
3. Listen to a lecture explaining the ratio of turns to voltage in a power transformer.
4. Watch a demonstration of how to interpret the position of the pointer on a volt-ohm-meter in terms of AC volts.

LABORATORY. Students will:

1. Trace windings on IF, audio and power transformers with the volt-ohm-meter.
2. Connect a high resistance DC relay to the DC power supply and measure the amount of current necessary to operate the relay.
3. Connect the highest resistance winding of a power transformer to 6.3 volts AC and measure the voltage across all other windings. From these measured values, students will compute the various turn ratios used in the transformer.

Week 5

DISCUSSION PERIOD. Students will:

1. Listen to a lecture describing the physical construction of various types of fixed and variable capacitors. During the lecture samples of each type of capacitor will be inspected by the students.
2. Listen to a lecture describing, in non-technical terms, the unit of measurement for capacitance.
3. Listen to a lecture describing how the electronic color code is used to mark capacitors.
4. Watch a demonstration of how to charge and discharge a capacitor. The demonstration will include the effect of a series resistance on the charging and discharging current and time.

LABORATORY. Students will:

1. Translate at least six different color combinations into capacitance, tolerance and voltage values.
2. Locate at least six different capacitance values by their color markings from a large group of capacitors.
3. Charge several different capacitors by connecting them directly across the DC power supply. Students will then discharge the capacitors with a wire short.
4. Charge several different capacitors by connecting them across the DC power supply through a series resistor. Students will record the time taken for a complete charge and the peak charging current.

Week 6

DISCUSSION PERIOD. Students will:

1. Watch a demonstration of how to connect and operate an audio signal generator in the laboratory.
2. Listen to a non-technical lecture on how the trace is produced on the face of an oscilloscope.
3. Watch a demonstration on how to connect and operate an oscilloscope to produce a steady picture of a sine wave.

LABORATORY. Students will:

1. Connect the 6.3 volt AC output of the power supply to the vertical input of the oscilloscope and adjust the oscilloscope to produce a steady picture showing two cycles of the 60 Hertz sine wave.
2. Connect the output of the audio signal generator to the vertical input terminals of the oscilloscope and adjust for a steady trace at several different frequencies.
3. Connect a set of headphones to the output of the audio signal generator and measure the frequency response of their hearing.

Week 7

DISCUSSION PERIOD. Students will:

1. Listen to a lecture and watch a demonstration of how to calibrate the vertical scale on the face of an oscilloscope in volts.
2. Watch a demonstration of how to measure DC and peak to peak AC voltages.

LABORATORY. Students will:

1. Calibrate the vertical scale on the face of an oscilloscope in volts.
2. Connect the audio signal generator to the vertical input terminals of the oscilloscope at a specified frequency and measure the peak to peak output voltage at three different settings of the output control.
3. Connect a battery in series with the audio signal generator and measure the positive and negative peak of generator output.
4. Connect the 6.3 volt AC output of the power supply to the oscilloscope and measure its peak to peak value.
5. Connect the 115 volt AC output from an electrical outlet and measure its peak to peak value.

Week 8

DISCUSSION PERIOD. Students will:

1. Listen to a lecture explaining the formation of Lissajous patterns on the face of an oscilloscope.
2. Watch a demonstration of frequency measurement using a Lissajous pattern.
3. Watch a demonstration of phase measurement using a Lissajous pattern.

LABORATORY. Students will:

1. Connect an audio signal generator to the vertical input terminals of the oscilloscope and measure at least three different frequencies against a 60 Hertz reference.
2. Adjust the audio signal generator to 60 Hertz and record the patterns for at least three phase differences between the generator and reference signals.
3. Calibrate the audio signal generator against a 60 Hertz power source on as many ranges as possible.

Week 9

DISCUSSION PERIOD. Students will:

1. Listen to a lecture explaining the operation of a Wheatstone bridge circuit and its application as a resistance measuring device.
2. Watch a demonstration of resistance measurement using a breadboarded Wheatstone bridge circuit built with standard components.

LABORATORY. Students will:

1. Construct a Wheatstone bridge circuit on a breadboard using standard laboratory components.
2. Use the bridge to measure at least three marked and three unmarked resistances.
3. Determine which ratio arm provides the easiest and most accurate balance.

Week 10

DISCUSSION PERIOD. Students will:

1. Listen to a lecture explaining the terms "efficiency" (of an electrical device or circuit) and "power gain".
2. Watch a demonstration of how to interpret the position of a pointer on a wattmeter.
3. Watch a demonstration of how to measure power with a wattmeter and how to determine efficiency and power gain from the measurements.

LABORATORY. Students will:

1. Use a voltmeter and ammeter to measure the power used by a device.
2. Use a wattmeter to measure the input and output power of a device.
3. Determine the efficiency and power gain of the device from the measurements taken.

Week 11

DISCUSSION PERIOD. Students will:

1. Listen to a lecture explaining the causes of inaccurate electrical measurements made with meters.
2. Watch a demonstration of inaccurate measurements resulting from meter tolerances, different meter sensitivities, different circuit loads, and different interpretations of the values indicated by the position of the pointer.

LABORATORY. Students will:

1. Construct a resistive circuit having a variety of lead resistors available.
2. Individually measure currents and voltages with at least two different instruments under a variety of load conditions.
3. Determine and explain the percentage of error between measurements made on the same circuit with different instruments, and measurements made on the same circuit by other students.

Week 12

DISCUSSION PERIOD. Students will:

1. Watch a demonstration of how to use an industrial type Wheatstone bridge to measure a resistance.
2. Listen to a lecture explaining the problems encountered when using the bridge to measure very small or very large resistance.

LABORATORY. Students will:

1. Use an industrial type Wheatstone bridge to measure at least six different resistances that fall within the normal range of the instrument. Students will then measure the same resistances on a volt-ohm-meter and compare results.
2. Individually measure at least one very small and one very large resistance.
3. Determine and explain the variation in results made by different students measuring the same resistance.

Week 13

DISCUSSION PERIOD. Students will:

1. Listen to a lecture explaining how precise DC voltage and current measurements can be made with a potentiometer and standard cell.
2. Watch a demonstration of a voltage measurement made with a precision potentiometer, voltage multiplier, and standard cell.

LABORATORY. Students will:

1. Measure the voltage of a battery cell using industrial type potentiometer equipment.
2. Measure a high DC voltage using the voltage multiplier with the potentiometer equipment.
3. Check the calibration of a volt-ohm-meter on the DC voltage ranges by comparing a variety of measurements made on the volt-ohm-meter with those ma-e with the potentiometer equipment.

Week 14

DISCUSSION PERIOD. Students will:

1. Listen to a lecture explaining the principle of an industance and a capacitance bridge.
2. Listen to a lecture explaining in non-technical terms, the unit of measurement for inductance.
3. Watch a demonstration of how to use an industrial type impedance bridge to measure the sizes of a resistor, and inductor and a capacitor.

LABORATORY.

Students will use an industrial type impedance bridge to measure the values of at least:

1. Three resistances.
2. Three inductances.
3. Three capacitances.

Week 15

DISCUSSION PERIOD. Students will:

1. Watch a demonstration of how to connect and operate a radio frequency signal generator in the laboratory.
2. Watch a demonstration of how to connect and operate an electronic digital counter in the laboratory.
3. Watch a demonstration of how to measure frequency with a digital counter.
4. Watch a demonstration of how to check the frequency with a radio receiver.

LABORATORY. Students will:

1. Place the radio frequency generator in operation and observe the output waveform on an oscilloscope with and without modelation.
2. Use the calibrated audio frequency signal generator as a reference and measure the frequency of a signal from the radio frequency generator using a Lissajous pattern.
3. Use the digital counter to measure the same frequency output from the radio frequency signal generator.
4. Use the radio frequency signal generator to check the calibration of a radio receiver tuning dial.
5. Construct a circuit with the digital counter to measure their "reaction time" in response to a randomly operated alarm signal.

Week 16

DISCUSSION PERIOD. Students will:

1. Listen to a lecture explaining the purpose of the DC vacuum tube voltmeter.
2. Watch a demonstration of how to interpret the position of the pointer on the various cacuum tube voltmeter scales.
3. Listen to a non-technical lecture describing the decibel and how it is measured.
4. Watch a demonstration of how to make all of the different measurements for which the vacuum tube voltmeter was designed.
5. Watch a demonstration of how to connect and use an industrial type chart recorder.

LABORATORY. Students will:

1. Use the vacuum tube voltmeter to measure at least:
    a. Three different DC voltages
    b. Three different AC voltages.
    c. Three different resistances.
    d. One output in decibels.

2. Construct a voltage divider of resistances that will allow the vacuum tube voltmeter to make a reasonably accurate measurement while the volt-ohm-meter makes a very inaccurate one.
3. Connect the chart recorder and the vacuum tube voltmeter to a varying source of DC voltage and compare the accuracy of the two instruments.

605-100 Electronics Instrumentation

Evaluation - End of course performance test

This performance test was constructed to test for the accomplishment of the behaviorally stated student performance objectives for the course 605-100 Electronics Instrumentation. The performance objectives evaluated by each test item are identified. A copy of the course objectives is enclosed.

Please evaluate this performance test in accordance with its ability to measure the performance called for by the course objectives. Ideally, the best test conditions are on the job. However, in the classroom it appears that the best performance test is a simulation of the job behavior. Also, please comment on the type of test items best suited for performance measurement.

WAUKESHA COUNTY TECHNICAL INSTITUTE

Evaluation

605-100

Given sufficient time even the uninformed may be able to read instructions and perform most, if not all, of the tasks outlined below. Therefore, to make the evaluation truly indicative of having acquired a skill, a time factor has been included. The maximum time allowed for the completion of each task is shown in parenthesis.

Evaluation Tasks	Objectives Evaluated
1. The student will walk to a table holding at least 50 different electronics components and select the following (5 minutes):	1, 2

  a. 47K, ½ watt fixed resistor
  b. 250K potentiometer
  c. 680pf mica capacitor
  d. 330pf ceramic capacitor
  e. .luf, 200 volt capacitor
  f. 40uf, 450 volt electrolytic capacitor
  g. variable capacitor
  h. power transformer
  i. audio transformer
  j. intermediate frequency (IF) transformer
  k. radio frequency choke coil
  l. broadcast frequency oscillator coil
  m. power supply filter choke coil
  n. silicon diode
  o. transistor
  p. silicon controlled rectifier
  q. vacuum tube
  r. gas tube
  s. integrated circuit

Evaluation Tasks	Objectives Evaluated
2. From a given schematic diagram of a transistor amplifier, the student will select the correct parts and construct the circuit on a breadboard. (5 minutes)	1, 2, 3
3. From a given schematic diagram of a four resistor series-parallel network, the student will breadboard the circuit, connect the appropriate source voltage, and make the following measurements:	1, 2, 3, 4, 5, 6, 7

a. (5 minutes) With 50 volts DC applied, use a volt-ohm-meter to measure:

(1) the voltage across each resistor
(2) the total current supplied by the source; and the current through the 18K resistor.

b. (3 minutes) With 12.6 volts, 60 Hertz AC applied, use the vacuum voltmeter to measure:

(1) the voltage across each resistor
(2) the DB output across the 18K resistor

c. (2 minutes) With no voltage applied, use the vacuum tube voltmeter to measure the total resistance of the four resistor network.

d. (5 minutes) With 5 volts, 2,000 Hertz AC applied from an audio signal generator, use the oscilloscope to measure the peak to peak voltage across each resistor.

4. The student will connect the output of an audio signal generator to the vertical input terminals of an oscilloscope. 6, 7

a. (5 minutes) Using a Lissajous pattern, he will adjust the signal generator frequency to 180 Hertz as measured against the line frequency of 60 Hertz.

b. (3 minutes) The student will then adjust the oscilloscope and generator to display two cylces of the 180 Hertz sine wave with a peak to peak amplitude of 4 volts.

c. (5 minutes) Again using a Lissajous pattern, the student will set the generator to 60 Hertz and display a trace indicating the generator frequency is 90 degrees out of phase with the line frequency.

5. The student will place a radio frequency generator in operation and adjust the frequency to produce an output at 700 kilo Hertz. (8 minutes) 8, 1

a. The frequency setting of the generator will be verified by checking it against the calibrated dial of a radio receiver.

b. The frequency setting again will be verified by measuring it with an electronic digital counter.

6. The student will use an industrial type Wheatstone bridge to measure, within ± 1% the value of an unknown resistance. (3 minutes) 9

7. The student will use an industrial type impedance bridge to measure within ± 1% (10 minutes) 10

   a. The value of an unknown capacitance
   b. The value of an unknown inductance
   c. The value of an unknown resistance

8. The student will use a wattmeter to measure the AC line power consumed by a laboratory power supply adjusted to furnish 300 volts DC at 50 milliamperes. (5 minutes) 11

9. The student will connect a resistor, capacitor and toggle switch in series across a DC power source. A chart recorder will be connected across the capacitor to produce a picture of the voltage change when the switch connects the DC source to the circuit. (5 minutes) 14

10. A precision potentiometer and standard cell will be employed by the student to measure within ± ½% the terminal voltage of a flashlight dry cell. (5 minutes) 12

October 23, 1969

Mr. George A. McGuire
Curriculum Coordinator
Waukesha County Technical Institute
222 Maple Avenue
Waukesha, Wisconsin 53186

Dear Mr. McGuire:

Again I have to report that these materials are in pretty good shape. The evaluation guide is an excellent basis from which to prepare an examination and the student activities are generally relevant.

I have one suggestion that I do not want to include in my general comments, because it has to do with managing the faculty. As instructors succeed in clarifying their own objectives it becomes more and more apparent to them that their classroom activities are not strictly related to those objectives. This is not a comfortable discovery and sometimes causes them to slow their objective writing. The role of the instruction managers (administrators) is critical. Their role is that of moral support. The instructors are quite aware of the weaknesses in the objective statements and they are quite aware of the discrepancies between what they are doing in the classroom and what they want to achieve. They don't need anyone to point that out. What they do need is encouragement. Therefore, I suggest that administrators be advised not to pass judgment on the content of an objective; rather, they should be encouraged to glow whenever they see any kind of objective written down. If they do that the objective writer will feel more comfortable in suggesting modification and improvements.

But I do not want to imply that the objective is the most important element in an individualized system. In such a system the role of the instructor changes from that of transmitter to that of instructional manager, from that of a professional information sprayer to that of a professional consultant to the student. It would, therefore, be useful to observe an individualized system in action, even though it may not be functioning in a technical institute. There is one in your neighborhood that is probably the best in the country, and that is the Public School system of Duluth, Minnesota. If at all possible, I would send someone to spend a day or two looking over the strengths and weaknesses of their way of doing it (they have had five years experience), and looking over the various ways of handling the administrative and scheduling problems that may arise.

Mr. George A. McGuire
October 23, 1969
Page 2

But the materials you have sent tell me that you are in pretty good shape, and suggest to me that a significant portion of your facility may be ready to go. To help them along you might remind them that an individualized system is fail-safe system. The student is not released until he can perform as desired, regardless of how long this may take.

I look forward to the next phase.

Very sincerely,

Robert F. Mager

RFM:jm

REVIEW COMMENTS

October, 1969

GRADING

So that you might better evaluate my final comments let me begin with a little background on the topic of grading.

Just what is grading?

Grading is one result of evaluation. A grade represents a judgment, rather than a measurement. A grade (judgment) may or may not be based on one or more measurements, and if based on measurements, those measurements may or may not be relevant to the goals (i.e. it is no trick to make judgments without any information at all).

The next question is:

Why do we pass judgments through such means as grades? Why do we need such judgments? It seems to me there are two general reasons why such judgments are initiated.

1. A grade is used as a symbol to describe something about student achievement. For a grade to be a good descriptor one must then make sure that the measurements on which the grade (judgment) is based are relevant to the variables to be described. For example, if a grade is intended to describe something about how well a student can perform, then the grade (judgment) should be based on measurements of performance rather than measurements of attendance, deportment, attitude, or shoe size.

2. A grade is used as a guide to disposition. For example, if one intends to do three different things with different sized oranges, then one "grades" them into three sizes. Likewise, if different things will be done with students then as many grades as there are intended dispositions may be useful. But it makes little sense to grade oranges into four piles when there are only three bins to put them in; that is, when only three meaningful things will be done with them. Similarly, it makes little sense to grade students into five piles when only two things will be done with them (i.e. graduate them or reject them).

The above suggests that regardless of what the judgments are called (e.g. grades, pass-fail, go no-go) it is useful to have as many grades as there are intended dispositions. In addition, it is implied that a grade should be based on measurements that are relevant to the thing which the grade is expected to mean; the grade should be based on measurements that most relevantly measure the attribute to be evaluated.

Now to your situation. As you have indicated, you want the grade to reflect achievement. Therefore you propose a binary decision on each of the objectives, and then report the total number of objectives achieved. This seems to me like you would be reporting a measurement rather than a judgment. There is nothing wrong with reporting measurements so long as the person who will judge it knows what he is doing.

You also are considering eliminating the ABCDEF system. This may be a wise thing to do, but that should depend on your "political" situation rather than on the "technology" of grading. That is, such a grading system is often useful in communities where parents or college administrators insist on same. My feeling is that if letter grades are the kind of symbols your consumer insist on, I have no objection.

The point is that the A's and B's can mean any number of things, and the main thing is to make sure that the grades, whatever they are called, mean the best thing you can think of! Typically, the grade is just a judgment about the comparative standing of one student among his peers. The grade purports to say something about how much a student has remembered of whatever happended to have been offered him, in relation to the average performance of the neighbors who happen to be sitting around him.

I feel that if you want to you can retain the A's and B's (if it is politic to do so), but you can make them mean something better. For example, an "A" can reflect a judgment based on the number of objectives completed above some minimally acceptable number. Or, it can be a judgment about the amount of time taken during which to achieve a given number of objectives. Or it can be some combination of these. What we feel is important is not whether a judgment is called an "A" or something else, but whether the judgment reflects a comparison of one student's performance with intended performance, rather than a comparison of a student's performance with the average performance of the class. As you know, a grade that compares one student with the class average tells nothing whatever about whether the student achieved enough, or whether he achieved anything worthwhile. The best student in a given class may have achieved far less than is appropriate or desireable; the worst student in a given class may have achieved more than expected or desired.

So, after that long-winded discussion here are my specific comments on your proposed grading system.

First, I strongly agree to put a go-no-go criterion on each objective. Determine the criterion of successful performance as best you can, then stick to it--make no exceptions. If the student can perform the standard (or better), he is considered to have achieved the objective. If he has not performed to criterion he is judged not to have achieved the objective. If it becomes obvious that it was unreasonable to expect the student to achieve a given objective, you do not give the student a "no-go" on the objective. You mark it down to bad selection of objectives and omit that objective from the evaluation.

Second, I agree that it would be a large step forward to report what a student can do (achievement) rather than to merely report a letter that says something about what he knows in relation to what other people know. But one question is unanswered. That question is this: How will you prevent people from looking at the list of accomplishments and concluding that each of the students is incompetent or somehow not up to snuff? That is, if you report only the skills achieved, you leave to someone else the judgment about whether those skills are enough, about whether they were developed in long or short time, whether they represent good or poor performance in the eyes of an expert. And as you well know, people will make those judgments whether we like it or not.

Since we still live in a world where the ABC grading abounds, and in which people make judgments about students whether those judgments are sensible or not, how about considering a compromise, a transition. How about considering accomplishments along with a letter grade--a grade which reflects how many of the objectives assigned to each student were achieved in a given time? In this way you can help educate those who are still back in the "normal curve" days by providing the list of performances, and you can satisfy their maniacal need to label students by giving them a more meaningful grade than the ones they had before.

I do not believe you run a serious risk with such a compromise. After all, once you have objectives you will adjust your instruction until those objectives are achieved. Before long, therefore, just about everyone will be achieving all the objectives and just about everyone will be getting A's. This is as it should be, since the job of the schools should be to educate people, rather than to label people and fail people.

The practice assumes, however, that you are able to tolerate a situation in which you are completely successful, that is, a situation in which all students achieve most or all of the objectives. It also assumes that you are in an environment where you can "get away with" giving more than the asinine number of A's generally considered acceptable. If you can do that, you don't have a thing to worry about.

My final comment about your proposed system to report accomplishment and to use a binary judgment about whether a particular objective is achieved or not achieved is: Horray for you!

CRITERION TEST 605-100

You are in pretty good shape on the criterion test. The comments that I have related to relatively minor points.

It is an excellent practice to identify the objectives evaluated by a given class of test items, as you have done in the right hand margin. It is useful to take steps, however, to make sure that those who read this sheet do not misinterpret the meaning of the objective numbers. For example, item 2 "evaluates" objectives 1, 2, and 3. Actually, this means that the skills called for in objectives 1, 2, and 3 are also called for by the test items. But, the intent of item 2 is to assess objective # 3 only, that is, the object is to determine whether the student can construct the desired circuit. Your judgment about whether he can or not is based upon his responses to item 2.

The point is this. Only if you already know whether he has achieved objectives 1 and 2 can you make suitable judgments about the responses to item 2. It is quite possible, as you know, for a student to fail to construct the appropriate circuit--not because he doesn't know how to construct the circuit--but because he doesn't know how to select the proper parts. Thus, there is a danger of concluding that he has not achieved objective 3, when in fact he has not achieve objective 1. This is not to suggest that you do not want to measure multiple skills in a single test item, it is only to caution you against the hazard of judging a student to be poor at one skill when in fact is poor at another.

A typical example in the public schools of this kind of problem comes from mathematics. Very frequently the student is taught to solve equations in the classroom, and then given word problems on the test. Now the student may very well know how to solve the relevant equation and get the right answer, but he may not know how to set up a word problem (because he wasn't taught). But the evaluator says that he has failed at solving the equation--when actually he has only failed at setting up the equation. This form of interlocking test items (i.e. you can't possibly get the second part right unless you get the first part right) is to be avoided if you want to find out specifically whether he can perform the second part (second objective). They are OK if you want to find out whether he can perform the whole skill, and are not interested in a diagnosis of why the overall performance may be inadequate.

Perhaps if you put a circle around the appropriate objective number you might call attention to the specific objective to be tested by the item, and to the fact that skills called for by other objectives are also needed.

Item 3 calls for the student to make a number of different kinds of measurements. Actually you have several items here rather than a single item, and you might distribute the objective numbers beside the relevant parts of the item. Frankly, I don't understand why the objective allows a five minute time limit for each of the tasks, while the test items call for time limits varying from two minutes to five minutes.

Overall, the evaluation tasks look like something of a cross between a statement of objectives and actual test items. Certainly you would not say on a test paper "the student will walk to a table holding at least..." I feel what you are trying to do is to describe a class of test items so that someone can simply plug in different values and have a different item. This is fine, and will make a dandy document to give to the student (call it an Evaluation Guide). All you would have to do is to point out to him that specific values might be different than those shown on this sheet.

The next step, I think, will be to construct some real test items so that you can see what an actual test will look like. You can then check this against the objectives and to see whether it is practical in terms of time and facilities. Such a procedure should lead you back to the objectives, as you see where additional clarification is possible and is needed. For example, objective # 3 says "construct a circuit..." but might be clearer if it said "hook up a breadboard circuit..."

STUDENT ACTIVITIES

The main suggestion I have is to follow the same procedure you did with the test; namely, that of listing the objective number to which each of the activities relate. I feel that if you do this you will find that some of the activities currently listed are superfluous. At least, they are not relevant to the objectives that I have.

Please don't misunderstand. Just because an activity does not relate to a stated objective is not enough reason to throw it out. It is enough reason to be suspicious and to ask questions of the activity, but not enough reason to get rid of it. Some activities need to be included for interest, and some for continuity. For example, during week five the student will have to listen to a lecture describing the physical construction of capacitors. While the objectives call for him to be able to recognize capacitors, there is nothing that requires him to know how they are made. If the student finds it interesting to learn about how they are made, or if this information provides transition from one topic to another, then leave it in. If not, then it is unnecessary for the objectives as stated.

MOVING TOWARD INDIVIDUALIZED INSTRUCTION

There are probably any number of ways to move toward an individualized pattern of instruction. I can't tell which one might be best for you, but perhaps you can get some clues by reviewing the purposes of an individualized approach. One of these is to provide the freedom to move ahead at a rate consistent with the ability of the student. Another (and to me a more important one) is to provide a means by which the student is not required to study that which he already knows. A third is to provide a means by which the student can perceive his progress toward the development of important skills.

This leads to a number of implications. First is that some means must be developed for assuring the importance (relevance) of the curriculum. This means two things. One is that the curriculum should be described in terms of skills rather than in terms of pieces of content, and the other is that the objectives (which describe these skills) should be selected on the basis of the kind of need analysis you are already making. In other words, instead of wondering how much math can be taught in a given time, ask the consumers of your graduates what skills are needed. You need more than just a list of the technical skills that are relevant, however, because we know that something like 90% of the people who lose their job do so not because they lack technical skill but because they lack some sort of social skill. So it is one thing to know what a man must be able to do to keep a job. Clues to this can be obtained by asking your consumers to describe the characteristics of the men they have fired and of the men they do not intend to promote.

Another implication is that you need a way for the student to tell (1) whether he needs to spend time working toward a skill and (2) what elements of the skill he lacks. This means that skill-oriented objectives must be in the hands of the students and that he has the freedom to test his skill when he thinks he is ready. One of the goofiest assumptions we typically make is that a student knows nothing until we teach him otherwise; as a result we spend up to half or more of our time teaching him something he laready knows.

Another implication is that performance, rather than hours, be the primary yardstick. As you know, we currently use hours, so that a student is scheduled to be exposed to a given topic or activity for X hours--whether he needs it or not. The insanity of this is seen by wondering how the world would go if we operated our surgeries that way. (There is no implication that you must excuse a student from school or graduate him if he is able to perform as desired in less than the time allotted. That is easily handled by giving the student some options or free time, or more objectives to achieve. But it does imply that one does not demand that a student sit through instruction he doesn't need.)

So here are some intermediate steps you can take in your move toward an individualized program:

1. Prepare your objectives in terms of skill rather than content (put the content in the lesson plans, not in the objectives).

2. Make sure that none is allowed to give a lecture unless he is the same person who conducts the lab that follows. With this one move you will make all the lectures relevant to the lab, because the instructor will want to make sure during the class time that the students learn how to perform the lab exercises without blowing up the place. You will also get some good clues about which content is necessary to the objectives and which content is merely necessary to the instructor.

3. Begin to build a few instructional packages around single objectives using existing instructional materials. The contract thus given to the student would consist of a piece of paper headed by the objective, followed by a sample test item (to give him a good idea of what will be expected of him), followed by a list of relevant instructional sources or activities.

4. See if you can get a volunteer instructor to videotape the instructions (a mini-lecture) relevant to achievement of one of the objectives, and include that as one of the resources listed in the contract. Try it and modify it until it works, that is, until the student can achieve the objectives with the available resources. You can then begin to ease out of the lecture business while still having instructors useful in the lab. Ultimately, almost all your instructors will be helping the students to perform the target skills.

5. At the beginning use only volunteer instructors. Laggards can kill a project in more ways than you can kill a fly (that's fly buzz-buzz, not fly zip-zip)

RFM

FINAL CONSULTIVE PACKAGE

February 17, 1970

Dr. Robert F. Mager
13245 Rhoda Drive
Los Altos Hills, CA 94022

Dear Dr. Mager:

It was a pleasure to read your recommendations on Phase II of this study. We particularly enjoyed your comments on the proposed grading system and individualized instruction. As a result of the latter, we have chosen to include an instructional package for your viewing and recommendations in Phase III.

In this phase we will substitute the learning opportunities and end of the course performance tests for the course 605-102, Circuits I in preference for your recommendations on our first attempt at an instructional package. This package will be used in the course 605-102, Circuits I and it will include a learning opportunity and performance test for a specific behavioral objective. A slide-tape self-instructional presentation on Thevinin's Theorem is enclosed in the attached package. This slide-tape presentation is not yet of professional quality. We have some limitations in terms of equipment. The tape recording is at 3 3/4 IPS. The slides are numbered one through 24.

There are a few additional curriculum development procedures on which we would like to have your comments. In your book "Developing Vocational Instruction" I am referring to the "Preparation Phase" in program development. In our development procedures we desire to identify the target population before the student walks in the door. We want to gather objective evidence of student interest in the new program. Our concern is for the "how" in identifying the characteristics of the target population for a newly proposed program. Naturally, we would not go through all the procedures in program development if student interest is lacking. Approximately one-third of the students we serve (day school) come directly from the area high schools. Another one-third come from unskilled jobs or were unsuccessful at a four-year college, and the remaining one-third are veterans, come from relief rolls, or are unemployed married women. Presently, we initiate new programs upon requests from outside individuals or organizations and upon the best estimate of professional educators within the system.

Also, we would like your views on stating program and course prerequisites. Presently we use cut-off scores on the ACT, high school graduation, and a minimum of a "C" grade in certain high school courses as predictors of success in specific programs. Course prerequisites are stated in terms of previous courses to be taken in the program.

Page 2
Dr. Mager
February 17, 1970

In addition, would you comment briefly on the cooperative work-study program and its relationship to behavioral objectives. Can we expect industry to be responsible for the development of specific competencies with the learner?

I wish to express my personal satisfaction in corresponding with you on this study. Would your consulting services be available to us again at some future date? We would enjoy meeting you. We feel you have had a major impact on curriculum development in vocational-technical education in the 60's.

Sincerely,

George McGuire
Curriculum Coordinator

GM:ds

Enclosure

P.S. Please return the slide-tape presentation. It is our only copy. Also, would you address your reply to:
Mr. Walter Winter
Administrator of Research and Development
Waukesha County Technical Institute
222 Maple Avenue
Waukesha, Wisconsin 53186

Mr. Winter is co-director of this project.

INSTRUCTIONAL CONTRACT

Circuits I - 605-102 Thevinin's Theorem Estimated Time of Completion ________

OBJECTIVE:

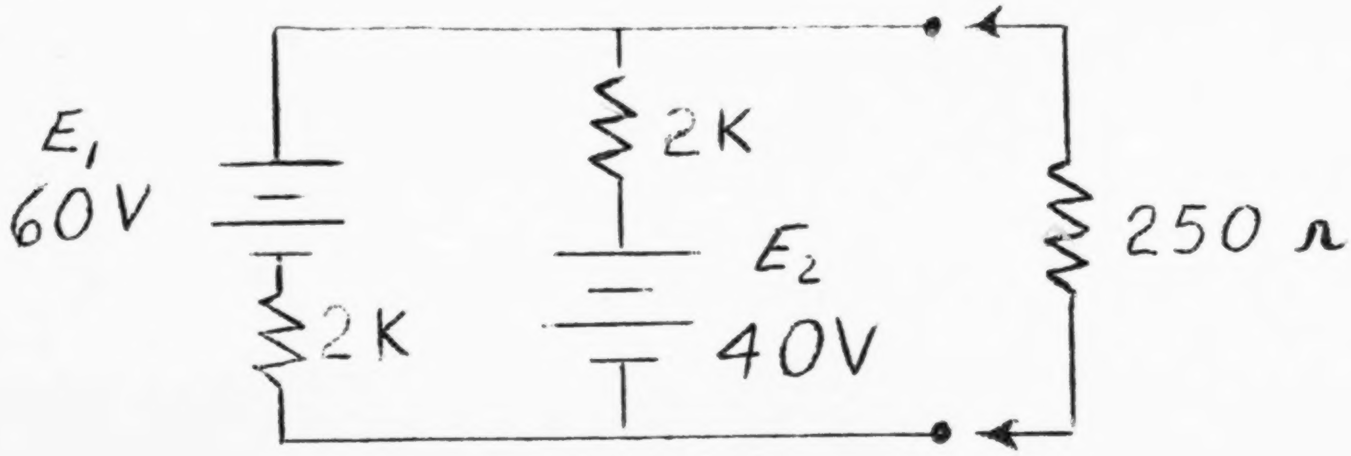
Given the source voltage and all resistance values for a circuit comprised of one or more generators connected in parallel across a load, you will be able to compute the power dissipated by the load through the application of Thevinin's Theorem.

Learning Opportunity

1. At the Educational Resource Center ask the A-V aide to set up the slide-tape presentation on Thevinin's Theorem. Be sure you have at least two pieces of scratch paper available. Be certain to take this instructional guide with you. When you hear the first beep on the tape, the slide viewed on the screen should read Thevinin's Theorem. Focus your projector using this slide. Perform all activities asked of you throughout the presentation. When you have successfully performed according to the directions given in the slide-tape presentation, you will be ready to take the self-test below.

Self Test

Solve for the Thevinin equivalent circuit giving the Thevinin voltage and Thevinin resistance. Then connect the load and compute the power dissipated.



Check your answers against those given on the back of this sheet. If you completed this self-test correctly, you have gained an additional circuit analysis skill in your career goal as an Electronics technician. You are now ready for acquiring an additional circuit analysis technique called Norton's Theorem.

Instructor ____________ Student ____________

Thevinin voltage 40 V

Thevinin resistance 1K

Power dissipated by the load 64 mw

March 10, 1970

Comments on Instructional Unit --
Thevenin's Theorem

You really have done a good job putting this unit together. There is good flow from beginning to end, and the illustrations are related to the audio.

Slide #10 is especially good, as it shows development step by step.

But the main thing to be proud of is that the unit exists. It has been designed and put together, and you have something to try out.

I have some comments relating to specific portions of the unit, but as you read them keep in mind that the number of specific comments is really a tribute to your work. If you hadn't created a unit as specific as this one there would be little to comment on.

1. "Theorem" in the title slide is misspelled. (Which "proves" that engineering professors should evaluate report grammar and spelling as well as the accuracy of the report...the packaging as well as the content.) The aside is pure soapboxing and should be ignored.

2. The tape repeats the objective as it is stated in the contract. This is OK, but I think you should try to open the tape with something designed to attract the attention and interest of the listener. Why should he care about Thevenin's theorem? What will it get him if he can use that tool? The tape says something like "Because the performance of the load represents the end result it is often desirable to analyze a circuit from the viewpoint of the load." But why? Because its intellectually stimulating? Or fun? What is MY payoff for learning how to use this tool?

You might briefly indicate the amount of calculations that might be saved, or the time that might be saved in a practical situation. Don't assume that the student is wild to learn about this thing just because it is the next item in the textbook or in the curriculum plan.

3. You might use the tape to paraphrase the objective. As I listened even the second time around two questions kept popping up at this point.

a. is the theorem only good for parallel circuits for sure?

b. how is it possible to connect a load "across" a load in series?

The value of the tape is that it can conversationally do what the text doesn't dare do, and that is to use everyday language to explain a point. You could explain to the student (if it is true) that any circuit connected to a load is connected across it and that therefore any circuit is connected in parallel with the load. Therefore the student doesn't have to learn how to discriminate among circuits for which the theorem applies and those for which it doesn't. At least that is what I got from the tape... but am not sure enough to have confidence in the conclusion. The same sort of thing may go on in the mind of your students, and a sentence or two might thus be useful.

4. In several places you use the usual anthropomorphic language that electronics people use so well. That's OK, too, but keep in mind that such language is meaningful only to those who are already sophisticated in electronics concepts, and are rather disconcerting to the novice. When we say things like "the load looks into a high impedance" we are using a vertal shorthand. If the student doesn't know the shorthand it will take him longer to learn the basic concept.

I don't recommend you not use such language, I only recommend you use it with caution. The way to do that is to be certain to test each draft of the script on one or two students who are near that level of development.

5. Slide 14 gave me a jolt and caused me to disconnect (stop listening) to the tape, because it looks as though you are applying 50 volts to the voice coil of an 8-ohm speaker. Memories of the smoke I have caused from mistakes concerning voice coils came flooding back and I had to stop the tape to get a better look at the slide.

6. My main comment...the one I consider most important...has to do with the consequence you use for practice questions, the thing the student "looks into" after he has tried to solve your practice items. In effect, the student is told

a. the correct answer

b. if correct, you did well

c. if incorrect, °check your work
°start at the beginning.

It seems to me that the primary intent of the unit is to teach the student a procedure, but that the feedback is entirely answer oriented. Further, the only feedback there is is the correct response. The student is not given information against which he can compare his procedure, nor is he given information about the common sources of error. He is told only that his answer is right or wrong, and then told to check his work and then, if that fails, to go through the instruction again. If the instruction was not adequate to cause the student to solve the problem the first time through, why should it be adequate the second time around? When we do this it is almost as though we were following a theorem which states that if you have a procedure that doesn't work, do it again.

Though I do not want to appear sarcastic with such a remark I do want to hit the point hard, as it is a "common problem" in a number of disciplines. Actually, the electronics world is not as problematical as some. In med schools, for example, there is an old saying that professors delight in flogging students with...."There is so much information to learn in this course that what you don't find in the lectures or in the texts, you'll find on the exams." And they look very smug with themselves as they utter the nonsense.

Back to the point. If we ask the student to engage in an activity and make a response it is appropriate to offer feedback regarding the appropriateness of the response, and assistance with poor responses. Though it is important for the student in this case to end up with the correct answer, it is more important for him to learn the steps of the procedure that are relevant to getting to that answer. Thus, I would suggest you make your feedback comments something like the following.

"In this problem the first thing to do is note that there are four sources and that each source has two resistances in series with it. The second step in the solution of this problem is to mentally (or with pencil) disconnect the load, so that the voltage across points A and B can be computed. As we have pointed out, we need to leave the circuit intact, with the exception of the load, so that this voltage can be calculated.

(then briefly tell how the voltage is computed)

"The next step is to determine the resistance between points A and B. Now is when you simplify the circuit by substituting a short for the source(s) and by combining resistances."

(Then briefly show how the answer comes out)

In this way the student will be able to compare his procedure with your procedure, and have a much better chance of determining how he went wrong.

Thus the way to go is to provide practice items, as you have done, and to follow the items with feedback regarding the important aspects of the student's activity, in this case the activity of carrying out the steps of the procedure.

7. When, as in this case, there is a step by step procedure to follow in the solution of a problem, you might very well make those steps visible to the student. You might tuck in a slide or two that lists the steps so that he has a better chance of seeing the whole concept at a glance. As it is you leave it to the student to conclude for himself whether (e.g.) one always computes voltage before simplifying the circuit, whether there are circuits for which the theorem isn't applicable and how one might recognize them, etc.

8. Taking the part of an ignorant student again for a moment, after going through the unit three times I am still not sure just what Thevenin's theorem is. I know how to solve the problems but what is the theorem? According to the tape the theorem is a proposal about what you can do with a circuit, about how you can look at a circuit. So I suspect that there is no equation involved. Is the theorem really just a point of view? My question is actually this: isn't there some way to visualize the essence of the theorem for the student so that he has something to hang the ideas on?

9. There are any number of people like myself who are happy to sit at our typewriters and pick the nits of your work. And some of what we have to say isn't bad...not bad at all. But in the case of instructional design the person who can provide the gold mine of useful information is the student, the target population. No matter what I might say here, the proof of the pudding and all that....is in the testing. Does it work? Does it work? Does the student develop the knowledge or skill the unit intends for him to develop? If it does, then the comments of colleagues should be given little or no weight. If it doesn't, you may get clues from colleagues but you will get firm information from the target population...through testing.

In a sense, it is like designing a circuit. You can show me your circuit design, and I will make some comment about how neatly you draw resistors, and about how elegantly you have used chokes to suppress those harmonics. And both of us will keep in mind that design errors can be made, that sneak circuits can slip into the picture, that components can do nasty things when they heat up to circuit temperature. We will know that no matter how long we pore over the design, we will only find out how good it is when we build the thing and plug it in. If it goes ZAP, and makes smoke, no amount of intellectualizing will alter the fact that alterations are in order.

The same is true of instructional design. If a unit is intended to achieve a result, we need to test the unit to find out if it does so. And the sooner the testing starts, the faster the unit will begin to work.

So (I knew I'd get to the point sooner or later), the most relevant suggestion I can make regarding your unit is to ask a student or two to work his way through it, note the problems and comments, and use them as a basis for redesign.

There is glorious satisfaction in the procedure. There is nothing so satisfying as listening to a heavily-degreed expert criticize an instructional unit, and then be able to reply..."but it works." Ahhhh...

10. The form of your contract is dandy. It is short, and devoid of obtuse verbiage (that means it's clear). But while I would be willing to agree that the student is ready for the criterion test...if he can pass the self-test, I don't think I would be willing to use the single item test as a basis for concluding that the student can perform the skill well enough to a. recognize when to use it

b. be able to use it for the variety of circuits he might meet.

Typically, in an individualized instruction system, the self-test is used as a device for helping the student determine when he is ready to ask for the criterion test. But if you do not intend for the student to be able to take such a test at his own convenience, then no modifications are required other than to add another item (or as many as are needed) so that the student can try his skill on the breadth of problems that will be representative of his job.

(Just in case I am using jargon when I say criterion test, such a test is the one used as the basis for the decision that the objective has been achieved. If you let the student make that decision, then in your case the self-test is the same as the criterion test.)

11. The slides are well done. There is no clutter, and they are to the point. If you are having trouble with lighting and slide quality, I am glad...glad. (I make my own slides and like to hear I'm not alone.)

Other Items

1. Your question about target population and their characteristics appears to have two parts. On the one hand you ask how to identify the characteristics of a population before they come in the door; on the other hand you say you would not bother to design a new program if interest is lacking. The latter concern is actually similar to (don't shoot) a marketing concern, where the question is one of how to determine which products to make. Your comment on how you now decide which programs to develop make me think that it is the "product-decision" problem that concerns you rather than the problem of how to find out what the people likely to come for courses are actually like.

Deciding what to do in the way of a course is a step that comes before the development phase, and is a question that can be answered in several ways; that is, there are several sources of information that might be used as a basis for such a decision. Requests from outside individuals or groups is a good one. Another is an analysis of the desires and aspirations of the target population. What are the hopes, the dreams of your T-Pop? How can you help them toward those goals? A survey of the needs of local industry is another source. Here you need be careful, however. Don't ask them what a person needs to know to do a certain job. Ask them what a person needs to do on the job. (If you ask about knowing they will simply feed back your course catalog to you.) You did well on your survey form; that is a good source of information.

If I were in your shoes I would ask a few students to design a survey form and go into the community to gather information from which to make some recommendations. They will take the assignment very seriously, and provide you with useful information.

Three months ago I gave our 13-year old the responsibility of recommending the make and model of the next family car. Once the job was his he took it very seriously, indeed, and for three months searched and read not only Popular Mechanics, but Consumer's Reports and some of the auto magazines. Each elimination was done on a sound basis. Finally the recommendation was made, and we followed it...to our complete satisfaction.

Course Prerequisites. Traditionally they have been used as a political tool, a device by which students could be accepted or rejected at the whim or necessity of the instructor. They have had little or no value as a means of insuring that specified skills would be in the repertoire of students entering a particular course.

If a prerequisite stated in terms of courses required is presented to give the student an idea of how elementary or advanced the course is to which they are attached, then it serves a useful purpose and might well be continued. If, on the other hand, the prerequisite is intended to specify the minimum level of skill that will be acceptable as entering behavior, then the listing of a course doesn't help much. A course title is not a description of a skill, nor is it an administrative structure that insists the skill(s) are necessary as the ticket to entry.

If, for example, the design of my course assumes that the entering student can already compute square roots on a slide rule, that means I do not intend to teach that skill, and it means I will likely make assignments that require use of that skill. The student with the skill will be able to learn what I have to teach him, the student without that skill will have difficulty.

If I intend to follow that scheme, then it is incumbent on me to make that skill requirement public so that others will be helped in their decision-making as it relates to entering my course. It is also incumbent on me to give entering students a prerequisite test, to help them see whether they are or are not qualified.

But if I really don't intend to stick to my prerequisite, either in the design of my course (oh, Ill give some tutoring) or in accepting or rejecting students (oh, I'll give him permission to enter anyhow), then the stating of prerequisites in terms of skill is hardly worth doing.

Not knowing your situation in more detail I would be kindest to refrain from making a specific recommendation, and content myself merely with the airing of the above comments.

Objectives and cooperative work programs.

Can we expect industry to be responsible for the development of specific competencies with the learner? I think a better question would be these: Can we get industry to accept responsibility for the development of specific skills? How can we get them to do so? (It would also be better if I could get my grammatical structures straight.)

One can influence the likelihood of specific skills being developed during a coop program by influencing the clarity of the intent. That is, if the company is provided with a clear statement of expectations there is a greater likelihood they will help achieve them. If the student has a similar statement he can help achieve them by asking for certain assignments, by asking for practice at relevant skills, by asking for information, and so on. This "statement of expectations," however, would not be a list of objectives in the sense that we understand that term. It would not be fair to expect that student supervisors can "read" objectives, any more than it is reasonable to expect that the prospective home builder can read blueprints. Rather, a paraphrasing of intents would seem to be more in order. There may not be much difference, but the intent would be to describe an intent in a way a supervisor would understand, rather than to prepare an objective that would be useful in instructional decision-making.

Further influence might be exerted if these intentions were prepared in the form of a checklist that the student could mark as he developed the intended skills. Not formal, but portable and visible.

And then, after the student has completed his stint, a letter of appreciation to the company would include a comment about the percentage of skill development expectations were achieved. To many companies it would be a revelation that you are concerned with exactly what the student learns there; such feedback might influence them to take a closer look at the student assignments.

From what I have seen regarding your plans and your efforts toward instructional design I can only say positive things about the direction you are taking. Vocational-technical education is far more important at this point in our history than the academic (see attached "On the Expansion of Personal Freedom"). Millions of high school graduates leave school able to perform only those unskilled jobs which no longer seem to exist in anything but paltry numbers. Thus the success of institutions such as yours may make the difference between success and failure of the society as we know it. We simply must accept as a high priority the job of teaching students how to DO meaningful things...otherwise, simply knowing meaningful things can lead to lack of pride and confidence -- and to failure.

I feel you are taking meaningful steps toward defining what is important, and you appear to be willing to change what is done in the classroom, as you have always been willing to change what you do as an engineer or technician. It has been a source of pride to have worked with you, and I hope it will be possible to do so again.

RFM

3/10/70

DISCUSSION

The procedures outlined in the "Method" section are basic to the "Closed Loop Systems Approach to Instruction". Through the systems approach we have the flexibility to utilize the best method to accomplish each objective with the learner. We believe that this approach is superior to others. Those institutions who commit themselves totally to one instructional system are apt to find that it, too, has limitations like the traditional approach to instruction. Our approach is that no one instructional system can do all things well. Therefore, we evaluate and select the best technique available for teaching each instructional objective.

The "Closed Loop Systems Approach to Instruction" is closely allied with the systems approach presently in effect at Oakland Community College, Orchard Ridge Campus in the State of Michigan. This is a learner centered approach, utilizing multi-media systems to provide group and individualized instruction. The strength of this plan is in its flexibility to meet the needs of the learner. We also choose not to commit ourselves to one method of organizing and teaching the curriculum but rather to remain flexible enough to utilize the best approach to teaching each course objective today and in the future. As new and better techniques for educating the student are developed, we will be prepared to evaluate and utilize those which best meet our needs.

Should this curriculum plan be adopted the Waukesha County Technical Institute will be the first Vocational, Technical, and Adult School District in Wisconsin to innovate a learner centered approach to instruction utilizing multi-sensory systems.

In occupational programs, where the emphasis is on physical skill development, it is important to state that providing appropriate practice is the most important learning process. Multi-sensory systems play a relatively minor role in physical skill development programs.

In addition, the procedures outlined previously in the "Method" section proved beneficial in the following ways:

1. Program and course offerings are more readily justified.
2. Employer may be guaranteed that graduates have, as a minimum, those skills necessary to enter the occupation.
3. Through the "Systems" approach reliable data can be gathered to give direction for the use of mulit-sensory systems in instruction.
4. Evidence may be collected to demonstrate that Waukesha County Technical Institute is consistently meeting the needs of the learner through offerings and programs of high quality.

SUMMARY AND CONCLUSIONS

The "Closed Loop Systems Approach to Instruction" developed for this study was derived from the assimilation of the works and concepts of many different professional vocational educators; from both within and outside our institution. Prominent among the works influencing the direction of this study are those listed on page 4 with special mention to Dr. Robert Mager, educator, author, and project consultant.

In order to generate the data base necessary to accomplish the objectives stated in Phases I and II; a survey instrument was developed and mailed to 287 different electronics oriented firms in three large midwest metropolitan areas. In addition to the mailed questionnaires seven personal interviews were conducted using the instrument as the medium for stimulating responses. The total number of firms contacted equaled 294.

Responses were analyzed according to metropolitan area, method of contact and technician design functions. No differences were observed in the responses analyzed according to metropolitan areas. Differences were observed for data analyzed according to method of contact and design functions. The differences noted between "mailed" and "personal" contact responses most likely is rooted in the large variance in the number of completed returns for each group. "Mailed Returns", N = 86; "Personal Returns", N = 7. The differences recorded between the two groups "designs" and "not designs" is basically a variance inherent in the design questions relating to that function and not in other skills and activities performed by electronic technicians.

The findings of this study produced a data base for successfully accomplishing all of the objectives stated in "Phase I" and objectives A, C, D, and E stated in "Phase II". The nature and extent of the objectives delineated in the original proposal correlate to those objectives that have been identified as being successfully completed.

Project directors conclude that the experience and evidence produced in this study substantiates the feasibility of "The Closed Loop Systems Approach to Instruction". Objective evidence has been collected which demonstrates the "System Approach" can:

1. Identify the characteristics of employed electronics technicians.
2. Clearly, without ambiguity, identify the tasks performed by electronic technicians on the job; from which educational requirements for the electronics occupations can be determined.
3. Identify the skills students need to acquire.
4. Assess student mastery of specific skills.
5. Identify the best techniques available for accomplishing behaviorally stated student performance objectives.
6. Assure a relevant curriculum and maintain relevance through established feedback channels.

It seems reasonable to further conclude that the "systems" approach is applicable to curriculum development; providing some modifications are made in terms of data collection, analysis and "system" implementation.

Instrument specificity needs to be refined and instrument complexity must be reduced. To be successful from the staff's point of view the implementation of a "system", as described in this study, would require more flexibility in terms of staff time, for curriculum development and system implementation. Given these considerations the study supports the feasibility and applicability of the "Closed Loop Systems Approach to Instruction".

It is recommended, by the project directors, that additional studies be made in other institutions and in other Associate Degree and/or Certificate Programs, utilizing experimental and control group concepts. Studies should also be conducted between like institutions so that the student support base would be adequate for this type of comparison.

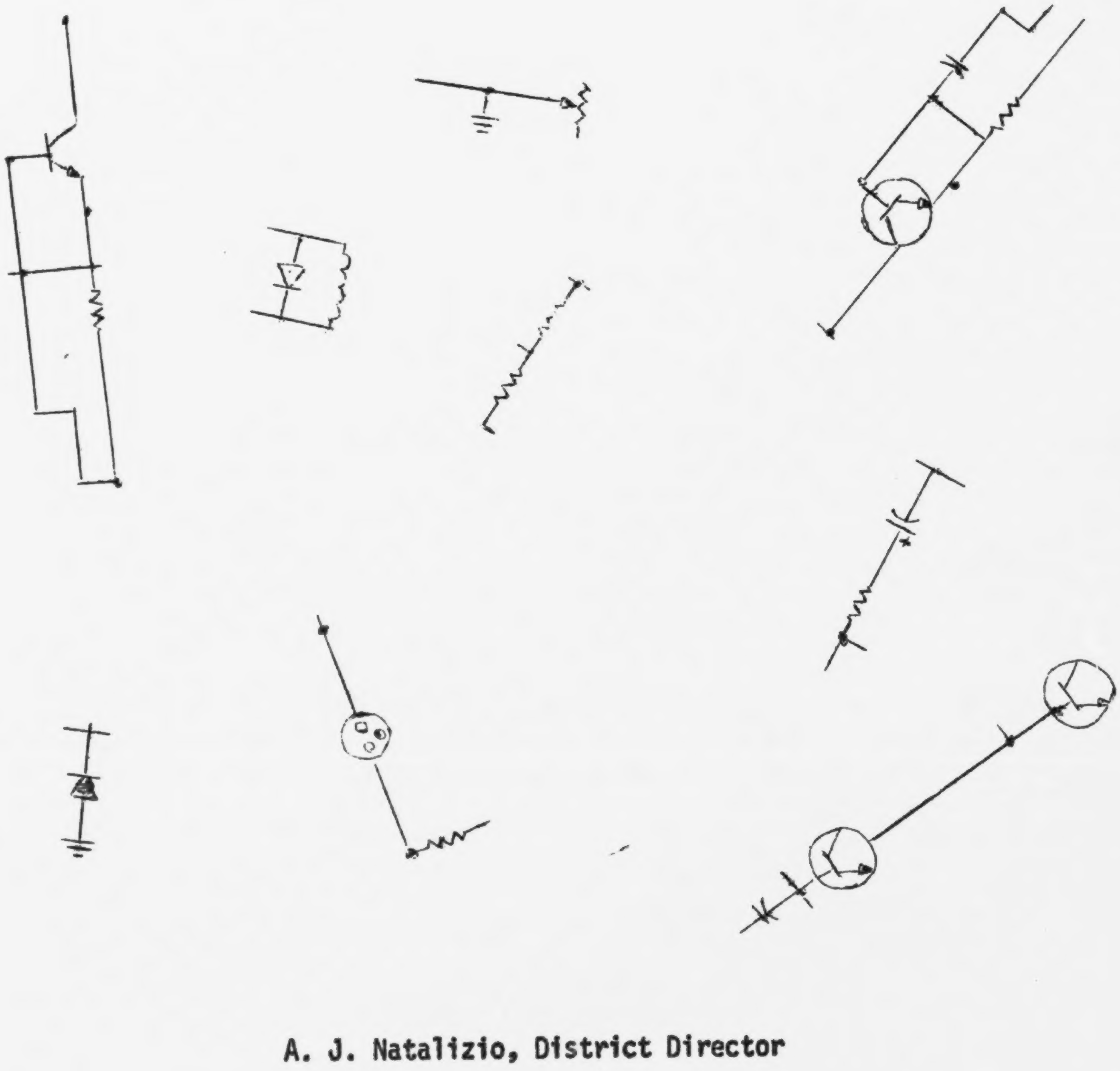
It is also recommended that additional study be continued in direct relation to this project so that all objectives stated herein might be fully realized. The fact that all the objectives stated in this report have not been accomplished in no way detracts from the fact that the original proposal objectives have, indeed, been successfully completed. However, much remains to be done.

The results of this study should be applicable to post-secondary vocational-technical institutions on a broad scale. If you have not already experimented with the "systems approach" to instruction employing measurable behavioral objectives, we highly recommend you do so.

ED0 48472

INSTRUCTIONAL SYSTEMS STUDY ELECTRONICS TECHNOLOGY

VOLUME II



VT012555 Part II

A. J. Natalizio, District Director

WAUKESHA COUNTY TECHNICAL INSTITUTE
AREA VOCATIONAL, TECHNICAL AND ADULT EDUCATION
DISTRICT #8

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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July 1969

You have been selected to share in a task analysis of the functions performed by electrical and electronic technicians in the Milwaukee Area, Chicago Area, and the Twin Cities Area.

The purpose of this task analysis is to continually verify and update the instruction in the Electronics Engineering Technology Program at the Waukesha County Technical Institute, Waukesha, Wisconsin and to make the results available to other similar institutions. We have been granted State and Federal funds for this research project. The outcome will be of benefit to you as we place graduates in the three major areas mentioned above. Your contribution will be an invaluable aid to our program development. Your replies will be kept confidential.

This questionnaire is to be completed by a supervisor of technicians or an electrical/electronic technician having a wide background of experience in the field.

It is requested that your questionnaire be returned to our office by August 1, 1969. Enclosed is a self-addressed, stamped envelope for your reply. PLEASE ENCLOSE POSITION DESCRIPTION AND DUTIES IF AVAILABLE. The results of this research can be made available to you on request. Thank you for your cooperation.

Sincerely,

WAUKESHA COUNTY TECHNICAL INSTITUTE

A. J. Natalizio

A. J. Natalizio, District Director

AJN:vb
Enclosures

WAUKESHA COUNTY TECHNICAL INSTITUTE

INSTRUCTIONAL SYSTEMS STUDY-ELECTRONICS TECHNOLOGY
1969

Please fill in the requested information and return this form in the self-addressed, stamped envelope to:

Waukesha County Technical Institute
222 Maple Avenue
Waukesha, Wisconsin 53186

Attention: Walter Winter, Administrator of Research & Development

---

BASIC INFORMATION

Please check the training requirements for your electrical-electronic technicians for job entry.

________High school.
________High school plus on the job experience.
________One to two years post-high school vocational training.
________One to two years post-high school vocational training plus on the job experience.
________Two years college level technical training (A.A.S.).
________Two years college level technical training plus experience.
________Military training.
________Other.

Do you have an apprenticeship program for electrical/electronic technicians?
________yes ________no

Do you provide in-plant training in electrical/electronic applications for your technicians? (other than apprenticeship).
________yes ________no

If yes, please specify the type of training provided.

____
____
____
____

Your use of electrical/electronic technicians in your organization is primarily
______manufacturing operations,______servicing,______design.

What electrical/electronic products do you manufacture?____________________
____
____
____

II. TASK ANALYSIS

Purpose: To identify the tasks performed by technicians in electrical and electronic occupations.

Directions: Please check the appropriate box for the given categories of each task. If the task does not apply to your technicians, leave the box blank.

TASKS PERFORMED BY TECHNICIAN	Frequency of Performance			Task Importance			Performance Difficulty		
	Daily	Occasionally	Rarely	Essential	Routine	Trivial	Difficult	Moderate	Easy
SAMPLE Solders with hand gun	✓				✓				✓
1. Orders supplies									
2. Solders electrical and electronic components									
3. Calibrates electrical and electronic test equipment									
4. Uses small hand tools									
5. Performs chassis layout									
6. Constructs prototype chassis									
7. Makes mechanical adjustments									
8. Makes mechanical repairs									
9. Interprets schematic diagrams									
10. Develops schematic diagrams									
11. Records instrument readings									
12. Maintains record of repairs on equipment									
13. Writes detailed electrical and electronic specifications									
14. Prepares evaluative reports on the performance of components, circuits and systems. Such reports are detailed requiring skill in technical writing.									

TASKS PERFORMED BY TECHNICIAN (Continued)	Frequency of Performance			Task Importance			Performance Difficulty		
	Daily	Occasionally	Rarely	Essential	Routine	Trivial	Difficult	Moderate	Easy
15. Installs electrical and electronic equipment									
16. Performs preventative maintenance									
17. Troubleshoots and repairs commercially produced electrical and electronic equipment									
18. Troubleshoots and repairs original in-house electrical and electronic equipment									
19. Performs tests on electrical and electronic components									
20. Performs tests on electrical and electronic circuits									
21. Performs tests on electrical and electronic systems									
22. Selects and applies appropriate electrical and electronic test equipment in testing, troubleshooting, and repair and in design applications									
23. Selects, compiles and applies technical information from engineering standards, handbooks, technical digests, etc.									
24. Analyzes and interprets information obtained from precision measuring and recording instruments and makes evaluations upon which technical decisions can be made.									
25. Analyzes and diagnoses technical problems that involve independent decisions									
26. Identifies controlling conditions of design problems.									
27. Researches existing circuits and components for design problem									

TASKS PERFORMED BY TECHNICIAN (Continued)	Frequency of Performance			Task Importance			Performance Difficulty		
	Daily	Occasionally	Rarely	Essential	Routine	Trivial	Difficult	Moderate	Easy
28. Constructs schematic diagram of a circuit to fulfill design conditions									
29. Selects components and related materials for circuit construction									
30. Physically constructs design problem									
31. Tests design for its ability to meet design conditions									
32. Modifies design									
33. Makes technical report on the design, its tests, and modifications									
34. Others -- (Please List)									

TASKS PERFORMED BY TECHNICIANS (Continued)	Performance Difficulty		
	Difficult	Moderate	Easy
The technician, upon performing the tasks selected previously, must exhibit a knowledge of: 35. Mathematics through Algebra			
36. Mathematics through Trigonometry			
37. Mathematics through Analytic Geometry and Calculus			
The technician, upon performing the tasks selected previously, must exhibit a knowledge of basic principles, laws, and concepts of physics including: 38. Mechanics			
39. Heat			
40. Sound			
41. Light			
42. Atomic Physics			
43. The scientific method of inquiry			
44. Principles of social psychology in maintaining good relations with fellow employees			
45. Basic principles, concepts and laws of chemistry			
46. Industry's organization and management			
47. Principles of industrial economics			

ELECTRICAL AND ELECTRONIC EQUIPMENT ANALYSIS

Purpose: To identify the type of equipment associated with the technician's performance.

Directions: The next few pages contain a list of equipment, tools, and measurements made in the electrical and electronic industries. This list is by no means complete as it is intended to cover the most common types. The list of equipment is divided into the categories of "Communications" and "Industrial". Listed separately, because they apply to both categories, are the test equipment and tools used by the technician.

We do not know which categories, "Communicatons" or "Industrial" is the primary area of specialization by your company. Consequently, please choose the most appropriate or both categories. Also, please make additions to the list as they apply to your operation.

COMMUNICATIONS

	Please check Type			Please check Technician's Activity			
	TUBE TYPE	SOLID STATE	MICROMINIATURE	TESTS & ADJUSTS	TROUBLESHOOTS & REPAIRS	DESIGNS	USES AS AN AID
1. AM Radio							
2. FM Radio							
3. HiFi Monaural Systems							
4. HiFi Stereo Systems							
5. Black & White Television							

	Please check Type			Please check Technician's Activity			
	TUBE TYPE	SOLID STATE	MICROMINIATURE	TESTS & ADJUSTS	TROUBLESHOOTS & REPAIRS	DESIGNS	USES AS AN AID
6. Color Television							
7. Closed Circuit TV Systems							
8. Monaural Tape Players							
9. Stereo Tape Players							
10. Video Tape Recorders							
11. Telephone Answering Systems							
12. Citizen's Band Two-way Radio Systems							
13. Short Wave Communications System							
14. Antenna Rotator Systems							
15. Electronic Garage Door Openers							
16. Intercom Systems							
17. Movie Projectors							
18. Power Amplifier Systems							
19. Electronic Ignition Systems							

	Please check Type			Please check Technician's Activity			
	TUBE TYPE	SOLID STATE	MICROMINIATURE	TESTS & ADJUSTS	TROUBLESHOOTS & REPAIRS	DESIGNS	USES AS AN AID
20. Inverters							
21. Battery Chargers							
22. Alarm Systems							
23. Radar Systems							
24. Microwave System							
25. Others (Please Specify)							

INDUSTRIAL

1. AC Motors							
2. DC Motors							
3. AC Generators							
4. DC Generators							
5. Alternators							
6. Motor Control Systems							
7. Generator Control Systems Systems							
8. X-Ray Equipment							

	Please check Type			Please check Technician's Activity			
	TUBE TYPE	SOLID STATE	MICROMINIATURE	TESTS & ADJUSTS	TROUBLESHOOTS & REPAIRS	DESIGNS	USES AS AN AID
9. Synchros							
10. Servomechanisms							
11. Timers							
12. Electric Brake							
13. Electric Clutch							
14. Ultrasonic Cleaner							
15. Ultrasonic Flaw Detector							
16. Induction Heating							
17. Dielectric Heating							
18. Photoelectric Control							
19. Welding Control Systems							
20. Electrostatic Percipitator							

	Please check Type			Please check Technician's Activity			
	TUBE TYPE	SOLID STATE	MICROMINIATURE	TESTS & ADJUSTS	TROUBLESHOOTS & REPAIRS	DESIGNS	USES AS AN AID
21. Ultraviolet Radiators							
22. Strip Chart Recorders							
23. X-Y Recorders							
24. Others (Please Specify)							

COMPUTERS AND RELATED EQUIPMENT

25. Card Punching Machines							
26. Card Processing Machines (sorting, collating, etc.)							
27. Card Readers and Printout							
28. Tape Producing Machines							

	Please check Type			Please check Technician's Activity			
	TUBE TYPE	SOLID STATE	MICROMINIATURE	TESTS & ADJUSTS	TROUBLESHOOTS & REPAIRS	DESIGNS	USES AS AN AID
29. Tape Readers							
30. Tape Storage							
31. Tape Reproducers							
32. Computer Control Counsol							
33. Digital Computer							
34. Analog Computer							
35. Others (Please Specify)							

Purpose: To identify the physical characteristics measured by electrical/ electronic technicians in performing their duties.

INDUSTRIAL

PLEASE CHECK:

_____ 1. Acceleration

_____ 2. Altitude

_____ 3. Color

_____ 4. Counting

_____ 5. Density

_____ 6. Dew-point Measurement

_____ 7. Displacement

_____ 8. Electrical Conductivity

_____ 9. Flow

_____ 10. Force

_____ 11. Gas Analysis

_____ 12. Gloss

_____ 13. Humidity

_____ 14. Length

_____ 15. Level

_____ 16. Light

_____ 17. Moisture Content

_____ 18. pH Measurement

_____ 19. Pressure

_____ 20. Rotation

_____ 21. Shock

_____ 22. Sound

_____ 23. Spectrum

_____ 24. Speed

_____ 25. Strain

_____ 26. Stretch

_____ 27. Temperature

_____ 28. Tension

_____ 29. Thickness

_____ 30. Turbidity

_____ 31. Vacuum

_____ 32. Vibration

_____ 33. Viscosity

_____ 34. Width

TOOLS

Purpose: To identify the tools used by Electrical/Electronic technicians in performing their duties.

PLEASE CHECK:

_____ 1. Needle nose pliers

_____ 2. Diagonal Cutters

_____ 3. Screw Drivers

_____ 4. Hex Nut Drivers

_____ 5. Soldering Gun

_____ 6. Soldering Iron

_____ 7. Soldering Aid

_____ 8. Heat Sink

_____ 9. Wire Brush

_____ 10. Tweezers

_____ 11. Welding Torch

_____ 12. Hammer

_____ 13. Sheet Metal Tools

_____ 14. Allen Wrenches

_____ 15. Wire Gauge

_____ 16. Spot Welder

_____ 17. Vise

_____ 18. Oven

_____ 19. Wire Stripper

_____ 20. Chassis Punches

_____ 21. Nibbler

_____ 22. Drill Press

_____ 23. Hand Drills

_____ 24. Soldering Pot

_____ 25. Others (Please Specify)

ELECTRICAL AND ELECTRONIC TEST EQUIPMENT

Purpose: To identify the test equipment associated with the electrical/ electronic technician's performance.

	Please check Type			Please check Technician's Activity			
	TUBE TYPE	SOLID STATE	MICROMINIATURE	TESTS & ADJUSTS	TROUBLESHOOTS & REPAIRS	DESIGNS	USES AS AN AID
1. VOM							
2. VTVM							
3. Audio Generator							
4. RF Generator							
5. Marker Generator							
6. Sweep Generator							
7. Oscilloscopes							

	Please check Type			Please check Technician's Activity			
	TUBE TYPE	SOLID STATE	MICROMINIATURE	TESTS & ADJUSTS	TROUBLESHOOTS & REPAIRS	DESIGNS	USES AS AN AID
8. Tube Testers							
9. Transister Testers							
10. Capacitor Analyst							
11. TV Analyst							
12. Color Bar/Pattern Generator							
13. Field Strength Meters							
14. Grid Dip Meters							
15. AC-DC Voltmeters							
16. AC-DC Ammeters							
17. Ohmmeters							
18. Electronic Switches							

	Please check Type			Please check Technician's Activity			
	TUBE TYPE	SOLID STATE	MICROMINIATURE	TESTS & ADJUSTS	TROUBLESHOOTS & REPAIRS	DESIGNS	USES AS AN AID
19. Bridges							
20. Square Wave Generator							
21. Decibel Meter							
22. VU Meter							
23. Wattmeter							
24. Instrument Transformer							
25. Growler							
26. Compass							
27. High Voltage Insulation Tester							
28. Prony Brake							
29. Tachometer							

	Please check Type			Please check Technician's Activity			
	TUBE TYPE	SOLID STATE	MICROMINIATURE	TESTS & ADJUSTS	TROUBLESHOOTS & REPAIRS	DESIGNS	USES AS AN AID
30. Megger							
31. Test Lamp							
32. Gieger-Mueller Counter							
33. Wave Meter							
34. Frequency Meter							
35. Noise Generator							
36. Electronic Counters							
37. Others (Please Specify)							

THANK YOU FOR YOUR COOPERATION!

DATA TABLES

The following summary of instrument responses are presented in the format in which the data was collected. The responses have been converted to percents and as the reader progresses throughout the data tables this conversion should be kept in mind.

Inasmuch as differences were not observed between "metropolitan areas" the data collected relevant to that category shall be reported herein as a composite data base. See Table #2. The data collected for the remaining categories ("personal interviews and mailed returns"; "designs and not designs") are presented as separate tables.

The results of this survey have served as a data base for: (1) validating course content; (2) formulating behaviorally stated performance objectives; (3) developing course objectives; (4) developing curricular materials; (5) developing student evaluation criteria; (6) determining target population characteristics.

TABLE #2

SUMMARY OF MAILED RETURNS

(Milwaukee, Chicago, and Minneapolis-St. Paul Areas)

Note: N = 86

I. Basic Information

Education and Training

High School	17%
High School plus on the job experience	17%
One to two years post-high school vocational training	37%
One to two years post-high school vocational training plus on the job experience	29%
Two years college level technical training (A.A.S.)	19%
Two years college level technical training plus experience	16%
Military training	24%
Other	2%

Do you have an apprenticeship program for electrical/electronic technicians?

Yes 11% No 89%

Do you provide in-plant training in electrical/electronic application for your technicians. (other than apprenticeship)

Yes 63% No 37%

Your use of electrical/electronic technicians in your organization is primarily maufacturing operations 45%, servicing 23%, and design 28%.

TABLE #2
(Continued)

II. TASK ANALYSIS	Frequency of Performance			Task Importance			Performance Difficulty		
	Daily	Occasionally	Rarely	Essential	Routine	Trivial	Difficult	Moderate	Easy
1. Orders supplies	7%	68%	25%	11%	72%	17%	4%	31%	65%
2. Solders electrical and electronic components	67%	29%	4%	53%	45%	2%	7%	55%	39%
3. Calibrates electrical and electronic test equipment	23%	52%	25%	62%	35%	3%	33%	58%	9%
4. Uses small hand tools	90%	10%		40%	56%	4%	3%	43%	54%
5. Performs chassis layout	7%	64%	29%	42%	48%	10%	21%	71%	8%
6. Construct prototype chassis	15%	66%	19%	55%	37%	8%	37%	58%	5%
7. Makes mechanical adjustments	41%	47%	12%	31%	64%	5%	9%	71%	20%
8. Makes mechanical repairs	35%	46%	19%	29%	62%	9%	7%	73%	20%
9. Interprets schematic diagrams	74%	24%	2%	83%	16%	1%	28%	64%	8%
10. Develops schematic diagrams	21%	46%	33%	62%	27%	11%	48%	45%	7%
11. Records instrument readings	63%	31%	6%	60%	37%	3%	6%	57%	37%
12. Maintains record of repairs on equipment	48%	32%	20%	35%	48%	17%		41%	59%
13. Writes detailed electrical and electronic specifications	2%	38%	60%	51%	27%	22%	54%	37%	9%
14. Prepares evaluative reports on the performance of components, circuits and systems. Such reports are detailed requiring skill in technical writing.	14%	44%	42%	67%	12%	21%	66%	30%	4%
15. Installs electrical and electronic equipment	27%	63%	10%	46%	51%	3%	23%	70%	7%
16. Performs preventative maintenance	28%	52%	20%	36%	54%	10%	23%	70%	7%
17. Troubleshoots and repairs commercially produced electrical and electronic equipment	26%	56%	18%	57%	41%	2%	40%	58%	2%

II. TASK ANALYSIS (Continued)	Frequency of Performance			Task Importance			Performance Difficulty		
	Daily	Occasionally	Rarely	Essential	Routine	Trivial	Difficult	Moderate	Easy
18. Troubleshoots and repairs original in-house electrical and electronic equipment	26%	64%	10%	56%	38%	6%	41%	54%	5%
19. Performs tests on electrical and electronic components	55%	38%	7%	53%	46%	1%	24%	62%	14%
20. Performs tests on electrical and electronic circuits	60%	34%	6%	66%	34%		28%	67%	5%
21. Performs tests on electrical and electronic systems	53%	44%	3%	73%	26%	1%	42%	57%	1%
22. Selects and applies appropriate electrical and electronic test equipment in testing, troubleshooting, and repair and in design applications.	66%	21%	13%	65%	32%	3%	36%	59%	5%
23. Selects, compiles and applies technical information from engineering standards, handbooks, technical digests, etc.	19%	48%	33%	32%	54%	14%	27%	62%	11%
24. Analyzes and interprets information obtained from precision measuring and recording instruments and makes evaluations upon which technical decisions can be made.	24%	53%	23%	67%	30%	3%	54%	43%	3%
25. Analyzes and diagnoses technical problems that involve independent decisions.	23%	50%	27%	62%	33%	5%	63%	37%	
26. Identifies controlling conditions of design problems.	8%	48%	44%	50%	35%	15%	63%	30%	7%
27. Researches existing circuits and components for design problem.	12%	52%	36%	57%	28%	15%	71%	23%	6%
28. Constructs schematic diagram of a circuit to fulfill design conditions.	7%	53%	40%	56%	32%	12%	47%	44%	9%
29. Selects components and related materials for circuit construction.	21%	50%	29%	51%	37%	12%	30%	63%	7%
30. Physically constructs design problem.	14%	44%	42%	48%	33%	19%	32%	59%	9%

	Frequency of Performance			Task Importance			Performance Difficulty		
II. TASK ANALYSIS (Continued)	Daily	Occasionally	Rarely	Essential	Routine	Trivial	Difficult	Moderate	Easy
31. Tests design for its ability to meet design conditions	38%	50%	12%	54%	41%	5%	31%	67%	2%
32. Modifies design	9%	56%	35%	58%	31%	11%	54%	44%	2%
33. Makes technical report on the design, its tests, and modifications	15%	58%	27%	53%	40%	7%	49%	49%	2%
The technician, upon performing the tasks selected previously, must exhibit a knowledge of:									
35. Mathematics through Algebra							11%	72%	17%
36. Mathematics through Trigonometry							14%	70%	16%
37. Mathematics through Analytic Geometry and Calculus							40%	32%	28%
The technician, upon performing the tasks selected previously, must exhibit a knowledge of basic principles, laws, and concepts of physics including:									
38. Mechanics							6%	89%	5%
39. Heat							8%	76%	16%
40. Sound							9%	70%	21%
41. Light							15%	70%	15%
42. Atomic Physics							12%	35%	53%
43. The scientific method of inquiry							21%	72%	7%
44. Principles of social psychology in maintaining good relations with fellow employees							19%	59%	22%
45. Basic principles, concepts and laws of chemistry							5%	55%	40%
46. Industry's organization and management							10%	52%	38%
47. Principles of industrial economics							10%	50%	40%

TABLE #2
(Continued)

III. EQUIPMENT ANALYSIS

The next few pages contain a list of equipment, tools, and measurements made in the electrical and electronic industries. This list is by no means complete as it is intended to cover the most common types. The list of equipment is divided into the categories of "Communications" and "Industrial". Listed separately, because they apply to both categories, are the test equipment and tools used by the technician.

We did not know which category, "Communications" or "Industrial" was the primary area of specialization by a company. Consequently a choice was made available for one or more categories.

	Please check type			Please check Technician's Activity			
COMMUNICATIONS	Tube Type	Solid State	Microminiature	Tests & Adjusts	Troubleshoots & Repairs	Designs	Uses as an Aid
1. AM Radio	7%	17%	3%	14%	15%	3%	2%
2. FM Radio	6%	19%	5%	16%	14%	3%	3%
3. HiFi Monaural Systems	3%	7%	1%	5%	6%	1%	1%
4. HiFi Stereo Systems	5%	13%		10%	12%	2%	2%
5. Black & White Television	12%	14%	3%	12%	15%	1%	2%
6. Color Television	9%	10%	5%	9%	10%	1%	2%
7. Closed Circuit TV Systems	6%	13%	2%	12%	10%	1%	1%
8. Monaural Tape Players	2%	12%	2%	8%	12%	1%	
9. Stereo Tape Players	1%	8%	1%	7%	7%	1%	1%
10. Video Tape Recorders	2%	3%	1%	7%	8%	1%	2%
11. Telephone Answering Systems	2%	3%	1%	2%	2%	1%	2%
12. Citizen's Band Two-way Radio Systems	2%	3%	1%	2%	2%	1%	
13. Short Wave Communications System	15%	7%	1%	6%	6%	5%	1%
14. Antenna Rotator Systems	2%	2%		2%	2%	1%	1%
15. Electronic Garage Door Openers	2%	5%		2%	2%	2%	

III. EQUIPMENT ANALYSIS (Continued)

COMMUNICATIONS	Please check type			Please check Technician's Activity			
	Tube Type	Solid State	Microminiature	Tests & Adjusts	Troubleshoots & Repairs	Designs	Uses as an Aid
16. Intercom Systems	6%	6%		5%	6%		1%
17. Movie Projectors	1%	1%		1%	1%		1%
18. Power Amplifier Systems	10%	20%	6%	17%	21%	3%	8%
19. Electronic Ignition Systems	2%	5%	1%	2%	1%	1%	2%
20. Inverters		13%		6%	8%	5%	3%
21. Battery Chargers	3%	14%		8%	10%	2%	6%
22. Alarm Systems	3%	8%		8%	6%	1%	1%
23. Radar Systems	3%	3%		3%	2%	2%	1%
24. Microwave System	2%	5%	2%	3%	6%	2%	1%
INDUSTRIAL							
1. AC Motors	3%	3%	1%	19%	22%	5%	20%
2. DC Motors	3%	2%	3%	20%	24%	3%	10%
3. AC Generators	3%	2%	1%	12%	9%	3%	16%
4. DC Generators	3%	2%	2%	12%	9%	2%	16%
5. Alternators	1%	1%	2%	8%	10%	2%	10%
6. Motor Control Systems	8%	14%	3%	26%	28%	7%	10%
7. Generator Control Systems	2%	5%		10%	9%	2%	6%
8. X-Ray Equipment	1%	3%		3%	2%	2%	1%
9. Synchros	1%	2%	2%	12%	12%	1%	7%
10. Servomechanisms	2%	10%	2%	19%	19%	3%	9%
11. Timers	8%	22%	1%	27%	34%	9%	16%
12. Electric Brake	2%	3%	2%	15%	20%	1%	5%
13. Electric Clutch	2%	6%	2%	16%	22%	2%	5%

III. EQUIPMENT ANALYSIS (Continued)	Please check type			Please check . nnician's Activity			
INDUSTRIAL	Tube Type	Solid State	Microminiature	Tests & Adjusts	Troubleshoots & Repairs	Designs	Uses as an Aid
14. Ultrasonic Cleaner	3%	5%		5%	9%		10%
15. Ultrasonic Flaw Detector		1%				1%	
16. Induction Heating		2%		7%	8%	2%	2%
17. Dielectric Heating	1%	2%		5%	6%	1%	1%
18. Photoelectric Control	6%	13%	1%	19%	29%	3%	7%
19. Welding Control Systems	2%	5%		5%	8%	2%	3%
20. Electrostatic Percipitator		1%		3%	3%		
21. Ultraviolet Radiators				2%	3%		
22. Strip Chart Recorders	6%	13%	1%	21%	17%	2%	16%
23. X-Y Recorders	2%	9%	2%	15%	17%	2%	16%
COMPUTERS AND RELATED EQUIPMENT							
25. Card Punching Machines	1%	5%	2%	6%	5%		5%
26. Card Processing Machines (sorting, collating, etc.)	1%	2%	2%	2%	2%	1%	2%
27. Card Readers and Printout	1%	7%	3%	8%	7%	2%	6%
28. Tape Producing Machines	1%	7%	5%	8%	8%	2%	3%
29. Tape Readers	1%	8%	3%	9%	9%	5%	3%
30. Tape Storage	1%	3%	2%	5%	3%		1%
31. Tape Reproducers	1%	2%	2%	5%	5%	2%	
32. Computer Control Counsol	1%	8%	5%	8%	7%	3%	6%
33. Digital Computer	1%	8%	3%	9%	9%	1%	7%
34. Analog Computer	1%	6%	2%	6%	6%	3%	3%

TABLE #2
(Continued)

IV. TOOLS

1. Needle nose pliers	95%	13. Sheet Metal Tools	58%
2. Diagonal Cutters	93%	14. Allen Wrenches	92%
3. Screw Drivers	97%	15. Wire Gauge	55%
4. Hex Nut Drivers	92%	16. Spot Welder	23%
5. Soldering Gun	80%	17. Vise	80%
6. Soldering Iron	93%	18. Oven	60%
7. Soldering Aid	65%	19. Wire Stripper	93%
8. Heat Sink	77%	20. Chassis Punches	71%
9. Wire Brush	70%	21. Nibbler	55%
10. Tweezers	84%	22. Drill Press	83%
11. Welding Torch	26%	23. Hand Drills	84%
12. Hammer	83%	24. Soldering Pot	55%

V. CHARACTERISTICS MEASURED BY INDUSTRIAL ELECTRONICS TECHNICIANS

1. Acceleration	21%	13. Humidity	42%	25. Strain	34%
2. Altitude	15%	14. Length	55%	26. Stretch	17%
3. Color	17%	15. Level	30%	27. Temperature	72%
4. Counting	58%	16. Light	29%	28. Tension	34%
5. Density	27%	17. Moisture Con.	23%	29. Thickness	49%
6. Dew-point Meas.	22%	18. pH Meas.	13%	30. Turbidity	5%
7. Displacement	29%	19. Pressure	36%	31. Vacuum	36%
8. Electrical Cond.	83%	20. Rotation	51%	32. Vibration	50%
9. Flow	29%	21. Shock	43%	33. Viscosity	13%
10. Force	40%	22. Sound	44%	34. Width	55%
11. Gas Analysis	9%	23. Spectrum	21%		
12. Gloss	5%	24. Speed	51%		

TABLE #2
(Continued)

VI. TEST EQUIPMENT	Please check type			Please check Technician's Activity			
	Tube Type	Solid State	Microminiature	Tests & Adjusts	Troubleshoots & Repairs	Design	Uses as an Aid
1. VOM	33%	51%	2%	35%	41%	6%	76%
2. VTVM	59%	45%	2%	33%	35%	6%	71%
3. Audio Generator	40%	34%		24%	29%	6%	38%
4. RF Generator	24%	22%	1%	15%	12%	3%	38%
5. Marker Generator	13%	12%		9%	6%	2%	17%
6. Sweep Generator	15%	17%		10%	8%	2%	24%
7. Oscilloscopes	64%	52%	2%	35%	36%	5%	77%
8. Tube Testers	36%	15%		20%	17%	2%	48%
9. Transister Testers	12%	55%	2%	17%	19%	5%	63%
10. Capacitor Analyst	24%	27%	1%	13%	15%	3%	49%
11. TV Analyst	3%	3%		1%	1%	1%	5%
12. Color Bar/Pattern Generator	7%	7%		3%	3%	1%	6%
13. Field Strength Meters	10%	15%		8%	7%	2%	17%
14. Grid Dip Meters	10%	8%		7%	6%	2%	20%
15. AC-DC Voltmeters	28%	35%	5%	23%	22%	3%	76%
16. AC-DC Ammeters	21%	31%	5%	21%	21%	3%	76%
17. Ohmmeters	24%	31%	5%	22%	21%	3%	77%
18. Electronic Switches	14%	24%	5%	22%	20%	9%	38%
19. Bridges	19%	26%		24%	17%	7%	60%
20. Square Wave Generator	21%	24%	1%	16%	15%	3%	42%

VI. TEST EQUIPMENT (Continued)	Please check type			Please check Technician's Activity			
	Tube Type	Solid State	Microminiature	Tests & Adjusts	Troubleshoots & Repairs	Designs	Uses as an Aid
21. Decibel Meter	14%	14%		16%	9%	3%	34%
22. VU Meter	6%	6%		8%	6%		16%
23. Wattmeter	13%	19%		20%	14%	3%	50%
24. Instrument Transformer	7%	8%		12%	10%	1%	30%
25. Growler	2%	2%		5%	2%	1%	9%
26. Compass	2%	3%		3%	2%	1%	10%
27. High Voltage Insulation Tester	15%	14%	1%	15%	15%	5%	3%
28. Prony Brake	1%	3%		2%	3%		12%
29. Tachometer	3%	13%	1%	12%	13%	3%	33%
30. Megger	13%	13%	1%	16%	12%	2%	47%
31. Test Lamp	12%	9%		12%	10%	1%	44%
32. Gieger-Mueller Counter	1%	2%		2%	2%		3%
33. Wave Meter	6%	7%		6%	7%	1%	12%
34. Frequency Meter	16%	23%	1%	14%	9%	5%	43%
35. Noise Generator	10%	10%		10%	7%	3%	21%
36. Electronic Counters	21%	38%		24%	29%	6%	57%

TABLE #3

SUMMARY OF PERSONAL INTERVIEWS

N = 7

I. Basic Information

Education and Training

High school plus on the job experience	14%
One to two years post-high school vocational training	14%
One to two years post-high school vocational training plus on the job experience	14%
Two years college level technical training (A.A.S.)	57%
Two years college level technical training plus experience	43%
Military training	43%

Do you have an apprenticeship program for electrical/electronic technicians?

Yes No 100%

Do you provide in-plant training in electrical/electronic applications for your technicians? (other than apprenticeship)

Yes 57% No 43%

Your use of electrical/electronic technicians in your organization is primarily manufacturing operations 63%, servicing 12% and design 25%.

TABLE #3
(Continued)

II. TASK ANALYSIS	Frequency of Performance			Task Importance			Performance Difficulty		
	Daily	Occasionally	Rarely	Essential	Routine	Trivial	Difficult	Moderate	Easy
1. Orders supplies		83%	17%	25%	75%			25%	75%
2. Solders electrical and electronic components	50%	50%		25%	75%			25%	75%
3. Calibrates electrical and electronic test equipment	43%	43%	14%	40%	40%	20%		40%	60%
4. Uses small hand tools	100%			20%	80%				100%
5. Performs chassis layout	17%	66%	17%	20%	80%			25%	75%
6. Construct prototype chassis	14%	57%	29%	25%	75%				100%
7. Makes mechanical adjustments	50%	50%		25%	75%			25%	75%
8. Makes mechanical repairs	43%	43%	14%	25%	75%			25%	75%
9. Interprets schematic diagrams	43%	43%	14%	25%	75%		25%		75%
10. Develops schematic diagrams	20%	40%	40%	25%	50%	25%		33%	67%
11. Records instrument readings	43%	57%		25%	50%	25%			100%
12. Maintains record of repairs on equipment		67%	33%	33%	67%				100%
13. Writes detailed electrical and electronic specifications			100%			100%		50%	50%
14. Prepares evaluative reports on the performance of components, circuits and systems. Such reports are detailed requiring skill in technical writing.	17%	66%	17%		100%			25%	75%
15. Installs electrical and electronic equipment		86%	14%	25%	75%				100%
16. Performs preventative maintenance	33%	17%	50%	50%	50%				100%
17. Troubleshoots and repairs commercially produced electrical and electronic equipment		80%	20%	33%	67%			33%	67%

II. TASK ANALYSIS (Continued)

	Frequency of Performance			Task Importance			Performance Difficulty		
	Daily	Occasionally	Rarely	Essential	Routine	Trivial	Difficult	Moderate	Easy
18. Troubleshoots and repairs original in-house electrical and electronic equipment	17%	83%		50%	50%				100%
19. Performs tests on electrical and electronic components	57%	43%		33%	67%			33%	67%
20. Performs tests on electrical and electronic circuits	33%	67%		33%	67%			33%	67%
21. Performs tests on electrical and electronic systems	17%	66%	17%	33%	67%			33%	67%
22. Selects and applies appropriate electrical and electronic test equipment in testing, troubleshooting, and repair and in design applications	25%	75%			100%				100%
23. Selects, compiles and applies technical information from engineering standards, handbooks, technical digests, etc.	25%	50%	25%	50%	50%				100%
24. Analyzes and interprets information obtained from precision measuring and recording instruments and makes evaluations upon which technical decisions can be made		75%	25%		100%				100%
25. Analyzes and diagnoses technical problems that involve independent decisions.	50%	25%	25%	100%					100%
26. Identifies controlling conditions of design problems	100%			100%					100%
27. Researches existing circuits and components for design problem	25%	25%	50%	50%	50%			50%	50%
28 Constructs schematic diagram of a circuit to fulfill design conditions	67%		33%	50%	50%				100%
29. Selects components and related materials for circuit construction		67%	33%		100%				100%
30. Physically constructs design problem			100%						

II. TASK ANALYSIS (Continued)	Frequency of Performance			Task Importance			Performance Difficulty		
	Daily	Occasionally	Rarely	Essential	Routine	Trivial	Difficult	Moderate	Easy
31. Tests design for its ability to meet design conditions	43%	57%			100%				100%
32. Modifies design	40%	40%	20%		100%			33%	67%
33. Makes technical report on the design, its tests, and modifications	25%	50%	25%		100%				100%
The technician, upon performing the tasks selected previously, must exhibit a knowledge to:									
35. Mathematics through Algebra								14%	86%
36. Mathematics through Trigonometry								86%	14%
37. Mathematics through Analytic Geometry and Calculus							57%	43%	
The technician, upon performing the tasks selected previously, must exhibit a knowledge of basic principles, laws, and concepts of physics including:									
38. Mechanics								14%	86%
39. Heat								43%	57%
40. Sound							40%	20%	40%
41. Light							40%	20%	40%
42. Atomic Physics							50%	25%	25%
43. The scientific method of inquiry								100%	
44. Principles of social psychology in maintaining good relations with fellow employees							14%	14%	72%
45. Basic principles, concepts and laws of chemistry							29%	71%	
46. Industry's organization and management							40%	60%	
47. Principles of industrial economics							50%	50%	

TABLE #3
(Continued)

III. EQUIPMENT ANALYSIS

The next few pages contain a list of equipment, tools, and measurements made in the electrical and electronic industries. This list is by no means complete as it is intended to cover the most common types. The list of equipment is divided into the categories of "Communications" and "Industrial". Listed separately, because they apply to both categories, are the test equipment and tools used by the technician.

We did not know which category, "Communications" or "Industrial" was the primary area of specialization by a company. Consequently a choice was made available for one or more categories.

	Please check type			Please check Technician's Activity			
COMMUNICATIONS	Tube Type	Solid State	Microminiature	Tests & Adjusts	Troubleshoots & Repairs	Designs	Uses as an Aid
1. AM Radio							
2. FM Radio		14%		14%	14%	14%	
3. HiFi Monaural Systems							
4. HiFi Stereo Systems							
5. Black & White Television							
6. Color Television							
7. Closed Circuit TV Systems							
8. Monaural Tape Players							
9. Stereo Tape Players							
10. Video Tape Recorders							
11. Telephone Answering Systems							
12. Citizen's Band Two-way Radio Systems							
13. Short Wave Communications System							
14. Antenna Rotator Systems							
15. Electronic Garage Door Openers							

III. EQUIPMENT ANALYSIS (Continued)	Please check type			Please check Technician's Activity			
COMMUNICATIONS	Tube Type	Solid State	Microminiature	Tests & Adjusts	Troubleshoots & Repairs	Designs	Uses as an Aid
16. Intercom Systems							
17. Movie Projectors							
18. Power Amplifier Systems		71%	41%	57%	57%	14%	29%
19. Electronic Ignition Systems							
20. Inverters		43%		29%	29%		14%
21. Battery Chargers		14%		14%	14%		
22. Alarm Systems		14%		14%	14%		
23. Radar Systems							
24. Microwave System							
INDUSTRIAL							
1. AC Motors					29%		14%
2. DC Motors					43%		14%
3. AC Generators							43%
4. DC Generators							14%
5. Alternators							
6. Motor Control Systems		43%		29%	71%		14%
7. Generator Control Systems		14%		14%	14%		
8. X-Ray Equipment		14%		14%	14%		
9. Synchros				43%	29%		29%
10. Servomechanisms		14%	14%	57%	43%	14%	14%
11. Timers		29%	14%	71%	57%	14%	14%
12. Electric Brake		14%		29%	14%		
13. Electric Clutch		14%		29%	14%		

III. EQUIPMENT ANALYSIS (Continued)

INDUSTRIAL	Please check type			Please check Technician's Activity			
	Tube Type	Solid State	Microminiature	Tests & Adjusts	Troubleshoots & Repairs	Designs	Uses as an Aid
14. Ultrasonic Cleaner							
15. Ultrasonic Flaw Detector							
16. Induction Heating							
17. Dielectric Heating							
18. Photoelectric Control		14%					14%
19. Welding Control Systems				14%	14%		14%
20. Electrostatic Percipitator							
21. Ultraviolet Radiators							
22. Strip Chart Recorders		43%					57%
23. X-Y Recorders		57%					57%
COMPUTERS AND RELATED EQUIPMENT							
25. Card Punching Machines							
26. Card Processing Machines (sorting, collating, etc.)						14%	14%
27. Card Readers and Printout						14%	14%
28. Tape Producing Machines							
29. Tape Readers							29%
30. Tape Storage		14%			14%		
31. Tape Reproducers							
32. Computer Control Counsol							
33. Digital Computer							
34. Analog Computer							

TABLE #3
(Continued)

IV. TOOLS

1. Needle nose pliers	100%	13. Sheet Metal Tools	71%
2. Diagonal Cutters	86%	14. Allen Wrenches	100%
3. Screw Drivers	100%	15. Wire Gauge	71%
4. Hex Nut Drivers	100%	16. Spot Welder	29%
5. Soldering Gun	86%	17. Vise	100%
6. Soldering Iron	100%	18. Oven	71%
7. Soldering Aid	86%	19. Wire Stripper	86%
8. Heat Sink	86%	20. Chassis Punches	100%
9. Wire Brush	86%	21. Nibbler	71%
10. Tweezers	100%	22. Drill Press	86%
11. Welding Torch	43%	23. Hand Drills	100%
12. Hammer	100%	24. Soldering Pot	71%

V. CHARACTERISTICS MEASURED BY INDUSTRIAL ELECTRONICS TECHNICIANS

1. Acceleration	43%	13. Humidity	57%	25. Strain	57%
2. Altitude	14%	14. Length	43%	26. Stretch	43%
3. Color	57%	15. Level	29%	27. Temperature	86%
4. Counting	86%	16. Light	29%	28. Tension	29%
5. Density	57%	17. Moisture Con.	43%	29. Thickness	57%
6. Dew-point Meas.		18. pH Meas.		30. Turbidity	
7. Displacement	29%	19. Pressure	86%	31. Vacuum	29%
8. Electrical Cond.	100%	20. Rotation	57%	32. Vibration	57%
9. Flow	29%	21. Shock	57%	33. Viscosity	14%
10. Force	43%	22. Sound	43%	34. Width	43%
11. Gas Analysis		23. Spectrum			
12. Gloss	14%	24. Speed	71%		

TABLE #3
(Continued)

VI. TEST EQUIPMENT	Please check type			Please check Technician's Activity			
	Tube Type	Solid State	Microminiature	Tests & Adjusts	Troubleshoots & Repairs	Design	Uses as an Aid
1. VOM	29%	29%		14%	14%	14%	86%
2. VTVM	57%	14%		14%	14%	14%	86%
3. Audio Generator	57%	14%		14%	14%	14%	71%
4. RF Generator	43%	29%		14%		14%	71%
5. Marker Generator	14%						29%
6. Sweep Generator	29%						29%
7. Oscilloscopes	86%	14%		14%	14%	14%	86%
8. Tube Testers	14%						14%
9. Transister Testers	14%	43%			14%		43%
10. Capacitor Analyst	29%	29%		14%		14%	43%
11. TV Analyst							
12. Color Bar/Pattern Generator							
13. Field Strength Meters	14%						14%
14. Grid Dip Meters							
15. AC-DC Voltmeters	29%						86%
16. AC-DC Ammeters	29%						86%
17. Ohmmeters	29%						86%
18. Electronic Switches							
19. Bridges				14%	14%	14%	57%
20. Square Wave Generator	43%			14%	14%		43%

VI. TEST EQUIPMENT (Continued)

	Please check type			Please check Technician's Activity			
	Tube Type	Solid State	Microminiature	Tests & Adjusts	Troubleshoots & Repairs	Designs	Uses as an Aid
21. Decibel Meter	14%						14%
22. VU Meter							
23. Wattmeter	29%						71%
24. Instrument Transformer	29%			14%	14%		57%
25. Growler							
26. Compass				14%		14%	
27. High Voltage Insulation Tester	29%			14%	29%	14%	57%
28. Prony Brake							
29. Tachometer		14%		14%	14%		57%
30. Megger							43%
31. Test Lamp				14%	14%		71%
32. Gieger-Mueller Counter	14%			14%	14%		
33. Wave Meter							
34. Frequency Meter	14%						14%
35. Noise Generator						14%	
36. Electronic Counters	14%	43%	14%	29%	29%	14%	57%

TABLE #4

SUMMARY OF DESIGNS GROUP

Note: N = 29

I. Basic Information

Education and Training

High School	17%
High School plus on the job experience	10%
One to two years post-high school vocational training	37%
One to two years post-high school vocational training plus on the job experience	48%
Two years college level technical training (A.A.S.)	31%
Two years college level technical training plus experience	31%
Military training	31%

Do you have an apprenticeship program for electrical/electronic technicians?

Yes 6% No 94%

Do you provide in-plant training in electrical/electronic application for your technicians. (other than apprenticeship)

Yes 58% No 42%

Your use of electrical/electronic technicians in your organization is primarily manufacturing operations 46%, servicing 27%, and design 54%.

TABLE #4
(Continued)

II. TASKS ANALYSIS	Frequency of Performance			Task Importance			Performance Difficulty		
	Daily	Occasionally	Rarely	Essential	Routine	Trivial	Difficult	Moderate	Easy
1. Orders supplies	5%	82%	13%	9%	82%	9%	14%	22%	64%
2. Solders electrical and electronic components	76%	24%		59%	41%		10%	45%	45%
3. Calibrates electrical and electronic test equipment	25%	61%	14%	74%	26%		43%	46%	11%
4. Uses small hand tools	89%	11%		29%	68%	3%	3%	40%	57%
5. Performs chassis layout	12%	80%	8%	48%	52%		20%	76%	4%
6. Construct prototype chassis	22%	78%		69%	31%		26%	74%	
7. Makes mechanical adjustments	31%	52%	17%	24%	66%	10%	14%	59%	27%
8. Mades mechanical repairs	30%	48%	22%	30%	52%	18%	8%	70%	22%
9. Interprets schematic diagrams	86%	11%	3%	81%	19%		36%	57%	7%
10. Develops schematic diagrams	26%	63%	11%	56%	37%	7%	48%	48%	4%
11. Records instrument readings	64%	32%	4%	54%	42%	4%	7%	68%	25%
12. Maintains record of repairs on equipment	37%	33%	30%	33%	48%	19%		59%	41%
13. Writes detailed electrical and electronic specifications	4%	38%	58%	61%	27%	12%	65%	23%	12%
14. Prepares evaluative reports on the preformance of components, circuits and systems. Such reports are detailed requiring skill in technical writing.	11%	52%	37%	84%	8%	8%	67%	29%	4%
15. Installs electrical and electronic equipment	18%	68%	14%	53%	43%	4%	25%	75%	
16. Performs preventative maintenance	15%	50%	35%	35%	46%	19%	4%	69%	27%
17. Troubleshoots and repairs commercially produced electrical and electronic equipment	27%	54%	19%	60%	40%		42%	58%	

II. TASK ANALYSIS (Continued)

	Frequency of Performance			Task Importance			Performance Difficulty		
	Daily	Occasionally	Rarely	Essential	Routine	Trivial	Difficult	Moderate	Easy
18. Troubleshoots and repairs original in-house electrical and electronic equipment	25%	61%	14%	57%	36%	7%	43%	53%	4%
19. Performs tests on electrical and electronic components	48%	48%	4%	55%	45%		31%	59%	10%
20. Performs tests on electrical and electronic circuits	59%	41%		76%	24%		35%	62%	3%
21. Performs tests on electrical and electronic systems	39%	61%		79%	21%		46%	54%	
22. Selects and applies appropriate electrical and electronic test equipment in testing, troubleshooting, and repair and in design applications.	68%	14%	18%	68%	28%	4%	43%	57%	
23. Selects, compiles and applies technical information from engineering standards, handbooks, technical digests, etc.	20%	52%	28%	34%	59%	7%	36%	57%	7%
24. Analyzes and interprets information obtained from precision measuring and recording instruments and makes evaluations upon which technical decisions can be made.	29%	53%	18%	68%	32%		66%	34%	
25. Analyzes and diagnoses technical problems that involve independent decisions.	15%	62%	23%	56%	44%		69%	31%	
26. Identifies controlling conditions of design problems.	17%	57%	26%	52%	44%	4%	70%	26%	4%
27. Researches existing circuits and components for design problem.	11%	64%	25%	70%	26%	4%	71%	25%	4%
28. Constructs schematic diagram of a circuit to fulfill design conditions.	7%	71%	22%	57%	39%	4%	43%	53%	4%
29. Selects components and related materials for circuit construction.	33%	52%	15%	52%	44%	4%	26%	70%	4%
30. Physically constructs design problem.	20%	52%	28%	40%	48%	12%	32%	64%	4%

II. TASK ANALYSIS (Continued)	Frequency of Performance			Task Importance			Performance Difficulty		
	Daily	Occasionally	Rarely	Essential	Routine	Trivial	Difficult	Moderate	Easy
31. Tests design for its ability to meet design conditions	45%	48%	7%	62%	38%		27%	73%	
32. Modifies design	4%	76%	20%	46%	46%	8%	46%	54%	
33. Makes technical report on the design, its tests, and modifications	15%	55%	30%	50%	50%		46%	54%	
The technician, upon performing the tasks selected previously, must exhibit a knowledge of:									
35. Mathematics through Algebra							29%	53%	18%
36. Mathematics through Trigonometry							17%	74%	9%
37. Mathematics through Analytic Geometry and Calculus							40%	40%	20%
The technician, upon performing the tasks selected previously, must exhibit a knowledge of basic principles, laws, and concepts of physics including:									
38. Mechanics							15%	85%	
39. Heat							17%	71%	12%
40. Sound							22%	56%	22%
41. Light							21%	63%	16%
42. Atomic Physics							12%	25%	63%
43. The scientific method of inquiry							23%	77%	
44. Principles of social psychology in maintaining good relations with fellow employees							21%	54%	25%
45. Basic principles, concepts and laws of chemistry							10%	52%	38%
46. Industry's organization and management							15%	50%	35%
47. Principles of industrial economics							19%	52%	29%

TABLE #4
(Continued)

III. EQUIPMENT ANALYSIS

The next few pages contain a list of equipment, tools, and measurements made in the electrical and electronic industries. This list is by no means complete as it is intended to cover the most common types. The list of equipment is divided into the categories of "Communications" and "Industrial". Listed separately, because they apply to both categories, are the test equipment and tools used by the technician.

We did not know which category, "Communications" or "Industrial" was the primary area of specialization by a company. Consequently a choice was made available for one or more categories.

	Please check type			Please check Technician's Activity			
COMMUNICATIONS	Tube Type	Solid State	Microminiature	Tests & Adjusts	Troubleshoots & Repairs	Designs	Uses as an Aid
1. AM Radio	10%	21%	3%	14%	21%	10%	3%
2. FM Radio	10%	24%	3%	17%	14%	10%	10%
3. HiFi Monaural Systems	3%	7%			3%	3%	3%
4. HiFi Stereo Systems	3%	21%		10%	14%	7%	7%
5. Black & White Television	7%	14%	3%	7%	14%	3%	3%
6. Color Television	10%	10%	3%	7%	7%	3%	3%
7. Closed Circuit TV Systems	3%	7%	3%	7%	3%	3%	
8. Monaural Tape Players		10%		3%	10%	3%	
9. Stereo Tape Players	7%	17%		7%	14%	3%	3%
10. Video Tape Recorders	3%	7%		3%	7%		
11. Telephone Answering Systems	3%	14%		10%	14%	3%	7%
12. Citizen's Band Two-Way Radio Systems	7%	10%	3%	7%	7%	3%	
13. Short Wave Communications System	7%	17%	3%	14%	14%	14%	3%
14. Antenna Rotator Systems	3%	3%		3%	3%	3%	3%
15. Electronic Garage Door Openers		7%		3%	3%	7%	

III. EQUIPMENT ANALYSIS (Continued)

	Please check type			Please check Technician's Activity			
COMMUNICATIONS	Tube Type	Solid State	Microminiature	Tests & Adjusts	Troubleshoots & Repairs	Designs	Uses as an Aid
16. Intercom Systems	3%	3%			3%		1%
17. Movie Projectors							
18. Power Amplifier Systems	7%	17%	7%	14%	14%	10%	7%
19. Electronic Ignition Systems	3%	7%	3%	3%	3%	3%	3%
20. Inverters		21%		3%	10%	14%	7%
21. Battery Chargers		21%		3%	10%	7%	10%
22. Alarm Systems		7%		7%	7%	3%	3%
23. Radar Systems	7%	7%		7%	7%	7%	3%
24. Microwave System	3%	7%		7%	7%	7%	3%
INDUSTRIAL							
1. AC Motors		10%	3%	13%	13%	13%	13%
2. DC Motors		7%	3%	10%	17%	10%	17%
3. AC Generators		7%		7%	7%	10%	14%
4. DC Generators		7%		7%	3%	7%	14%
5. Alternators		3%		3%	7%	7%	14%
6. Motor Control Systems	7%	28%	3%	24%	24%	21%	10%
7. Generator Control Systems		24%		24%	7%	7%	24%
8. X-Ray Equipment		7%		3%		7%	3%
9. Synchros	3%		7%	10%	10%	3%	10%
10. Servomechanisms	3%	10%	7%	28%	21%	10%	10%
11. Timers	3%	31%		28%	31%	28%	10%
12. Electric Brake	3%	3%		7%	10%	3%	
13. Electric Clutch	3%	7%		10%	10%	7%	

III. EQUIPMENT ANALYSIS (Continued)

INDUSTRIAL	Please check type			Please check Technician's Activity			
	Tube Type	Solid State	Microminiature	Tests & Adjusts	Troubleshoots & Repairs	Designs	Uses as an Aid
14. Ultrasonic Cleaner	3%	14%		7%	14%		14%
15. Ultrasonic Flaw Detector		3%				3%	
16. Induction Heating		7%		17%	21%	7%	
17. Dielectric Heating	3%	7%		14%	17%	3%	3%
18. Photoelectric Control	3%	21%		14%	24%	10%	3%
19. Welding Control Systems	3%	14%		10%	14%	7%	7%
20. Electrostatic Percipitator		3%		7%	7%		
21. Ultraviolet Radiators				3%	7%		
22. Strip Chart Recorders	3%	28%	3%	31%	28%	7%	31%
23. X-Y Recorders	3%	17%	3%	31%	31%	7%	21%
COMPUTERS AND RELATED EQUIPMENT							
25. Card Punching Machines		3%		3%	3%		7%
26. Card Processing Machines (sorting, collating, etc.)		3%				3%	7%
27. Card Readers and Printout		14%	3%	17%	7%	7%	14%
28. Tape Producing Machines		10%	7%	14%	10%	7%	10%
29. Tape Readers		17%	3%	21%	17%	14%	10%
30. Tape Storage				3%			3%
31. Tape Reproducers		3%		7%	3%	7%	
32. Computer Control Counsol		14%	7%	10%	7%	10%	10%
33. Digital Computer		7%	3%	7%	7%	3%	14%
34. Analog Computer	3%	14%	7%	14%	14%	10%	10%

TABLE #4
(Continued)

IV. TOOLS

1.	Needle nose pliers	100%
2.	Diagonal Cutters	97%
3.	Screw Drivers	100%
4.	Hex Nut Drivers	100%
5.	Soldering Gun	55%
6.	Soldering Iron	97%
7.	Soldering Aid	83%
8.	Heat Sink	93%
9.	Wire Brush	79%
10.	Tweezers	90%
11.	Welding Torch	28%
12.	Hammer	86%
13.	Sheet Metal Tools	79%
14.	Allen Wrenches	100%
15.	Wire Gauge	59%
16.	Spot Welder	28%
17.	Vise	86%
18.	Oven	79%
19.	Wire Stripper	93%
20.	Chassis Punches	90%
21.	Nibbler	76%
22.	Drill Press	93%
23.	Hand Drills	97%
24.	Soldering Pot	55%

V. CHARACTERISTICS MEASURED BY INDUSTRIAL ELECTRONICS TECHNICIANS

1.	Acceleration	24%
2.	Altitude	28%
3.	Color	17%
4.	Counting	62%
5.	Density	34%
6.	Dew-point Meas.	28%
7.	Displacement	31%
8.	Electrical Cond.	97%
9.	Flow	41%
10.	Force	45%
11.	Gas Analysis	17%
12.	Gloss	7%
13.	Humidity	48%
14.	Length	59%
15.	Level	31%
16.	Light	28%
17.	Moisture Con.	28%
18.	pH Meas.	24%
19.	Pressure	52%
20.	Rotation	55%
21.	Shock	59%
22.	Sound	48%
23.	Spectrum	34%
24.	Speed	59%
25.	Strain	55%
26.	Stretch	28%
27.	Temperature	86%
28.	Tension	45%
29.	Thickness	62%
30.	Turbidity	7%
31.	Vacuum	52%
32.	Vibration	66%
33.	Viscosity	21%
34.	Width	62%

TABLE #4
(Continued)

VI. TEST EQUIPMENT	Please check type			Please check Technician's Activity			
	Tube Type	Solid State	Microminiature	Tests & Adjusts	Troubleshoots & Repairs	Design	Uses as an Aid
1. VOM	34%	79%	3%	45%	48%	17%	86%
2. VTVM	66%	59%	3%	41%	34%	17%	76%
3. Audio Generator	48%	41%		31%	31%	17%	62%
4. RF Generator	34%	34%		21%	14%	14%	48%
5. Marker Generator	10%	17%		7%	7%	7%	14%
6. Sweep Generator	17%	31%		14%	14%	7%	31%
7. Oscilloscopes	76%	69%	3%	45%	41%	14%	86%
8. Tube Testers	41%	17%		17%	17%	7%	41%
9. Transister Testers	14%	79%		17%	28%	14%	76%
10. Capacitor Analyst	38%	41%		17%	24%	10%	62%
11. TV Analyst	3%	3%		3%	3%	3%	3%
12. Color Bar/Pattern Generator	7%	3%		7%	7%	3%	3%
13. Field Strength Meters	21%	17%		10%	10%	7%	24%
14. Grid Dip Meters	17%	17%		10%	10%	7%	21%
15. AC-DC Voltmeters	34%	48%	3%	31%	31%	10%	86%
16. AC-DC Ammeters	21%	38%	3%	28%	28%	10%	79%
17. Ohmmeters	24%	45%	3%	31%	31%	10%	90%
18. Electronic Switches	17%	21%	7%	31%	28%	28%	48%
19. Bridges	34%	28%		21%	24%	21%	62%
20. Square Wave Generator	24%	62%		31%	24%	10%	69%

VI. TEST EQUIPMENT (Continued)	Please check type			Please check Technician's Activity			
	Tube Type	Solid State	Microminiature	Tests & Adjusts	Troubleshoots & Repairs	Designs	Uses as an Aid
21. Decibel Meter	28%	31%		31%	24%	10%	52%
22. VU Meter	7%	7%		14%	14%		14%
23. Wattmeter	14%	14%		21%	17%	10%	38%
24. Instrument Transformer	14%	17%		14%	14%	3%	24%
25. Growler	7%	7%		7%	3%	7%	7%
26. Compass	21%	7%		10%	7%	3%	34%
27. High Voltage Insulation Tester	28%	38%		24%	28%		
28. Prony Brake							10%
29. Tachometer	3%	31%	7%	24%	31%	10%	38%
30. Megger	21%	24%	3%	24%	21%	7%	55%
31. Test Lamp	10%	17%		14%	14%	3%	45%
32. Gieger-Mueller Counter							
33. Wave Meter	10%	14%		10%	14%	3%	21%
34. Frequency Meter	14%	38%		21%	17%	14%	45%
35. Noise Generator	14%	17%		14%	14%	10%	31%
36. Electronic Counters	21%	59%		38%	38%	17%	72%

TABLE #5

SUMMARY OF NOT DESIGNS GROUP

Note: N = 57

I. Basic Information

Education and Training

High School	18%
High School plus on the job experience	21%
One to two years post-high school vocational training	37%
One to two years post-high school vocational training plus on the job experience	19%
Two years college level technical training (A.A.S.)	12%
Two years college level technical training plus experience	9%
Military training	21%

Do you have an apprenticeship program for electrical/electronic technicians?

Yes 13% No 87%

Do you provide in-plant training in electrical/electronic application for your technicians. (other than apprenticeship)

Yes 65% No 35%

Your use of electrical/electronic technicians in your organization is primarily manufacturing operations 54%, servicing 26%, and design 20%.

TABLE #5
(Continued)

II. TASK ANALYSIS	Frequency of Performance			Task Importance			Performance Difficulty		
	Daily	Occasionally	Rarely	Essential	Routine	Trivial	Difficult	Moderate	Easy
1. Orders supplies	9%	59%	32%	13%	64%	23%		34%	66%
2. Solders electrical and electronic components	63%	31%	6%	49%	47%	4%	4%	61%	35%
3. Calibrates electrical and electronic test equipment	21%	46%	33%	53%	42%	5%	26%	66%	8%
4. Uses small hand tools	91%	9%		47%	49%	4%	2%	45%	53%
5. Performs chassis layout	3%	53%	44%	36%	46%	18%	21%	67%	12%
6. Construct prototype chassis	8%	54%	38%	44%	41%	15%	47%	43%	10%
7. Makes mechanical adjustments	47%	45%	8%	35%	63%	2%	7%	78%	15%
8. Makes mechanical repairs	38%	45%	17%	29%	69%	2%	7%	75%	18%
9. Interprets schematic diagrams	67%	31%	2%	83%	15%	2%	25%	67%	8%
10. Develops schematic diagrams	16%	32%	52%	68%	18%	4%	48%	42%	10%
11. Records instrument readings	63%	30%	7%	65%	33%	2%	5%	50%	45%
12. Maintains record of repairs on equipment	55%	32%	13%	36%	47%	17%		28%	72%
13. Writes detailed electrical and electronic specifications		37%	63%	40%	28%	32%	40%	55%	5%
14. Prepares evaluative reports on the performance of components, circuits and systems. Such reports are detailed requiring skill in technical writing.	16%	37%	47%	48%	16%	36%	65%	31%	4%
15. Installs electrical and electronic equipment	33%	60%	7%	41%	57%	2%	22%	67%	11%
16. Performs preventative maintenance	37%	54%	9%	38%	59%	3%	5%	73%	22%
17. Troubleshoots and repairs commercially produced electrical and electronic equipment	26%	57%	17%	55%	43%	2%	38%	59%	3%

II. TASK ANALYSIS (Continued)

	Frequency of Performance			Task Importance			Performance Difficulty		
	Daily	Occasionally	Rarely	Essential	Routine	Trivial	Difficult	Moderate	Easy
18. Troubleshoots and repairs original in-house electrical and electronic equipment	27%	65%	7%	55%	40%	5%	41%	54%	5%
19. Performs tests on electrical and electronic components	59%	32%	9%	51%	47%	2%	19%	65%	16%
20. Performs tests on electrical and electronic circuits	61%	30%	9%	60%	40%		23%	70%	7%
21. Performs tests on electrical and electric systems	62%	33%	5%	69%	29%	2%	38%	60%	2%
22. Selects and applies appropriate electrical and electronic test equipment in testing, troubleshooting, and repair and in design applications.	65%	25%	10%	62%	35%	3%	32%	61%	7%
23. Selects, compiles and applies technical information from engineering standards, handbooks, technical digests, etc.	30%	48%	22%	17%	67%	16%	17%	67%	16%
24. Analyzes and interprets information obtained from precision measuring and recording instruments and makes evaluations upon which technical decisions can be made.	21%	53%	26%	66%	28%	6%	44%	50%	6%
25. Analyzes and diagnoses technical problems that involve independent decisions.	29%	41%	30%	67%	23%	10%	57%	43%	
26. Identifies controlling conditions of design problems.		41%	59%	48%	28%	24%	59%	36%	5%
27. Researches existing circuits and components for design problem.	13%	40%	47%	44%	30%	26%	71%	21%	8%
28. Constructs schematic diagram of a circuit to fulfill design conditions.	6%	37%	57%	55%	24%	21%	52%	33%	15%
29. Selects components and related materials for circuit construction.	10%	48%	42%	50%	30%	20%	33%	56%	11%
30. Physically constructs design problem.	8%	36%	56%	57%	17%	26%	33%	53%	14%

II. TASK ANALYSIS (Continued)	Frequency of Performance			Task Importance			Performance Difficulty		
	Daily	Occasionally	Rarely	Essential	Routine	Trivial	Difficult	Moderate	Easy
31. Tests design for its ability to meet design conditions	33%	52%	15%	49%	42%	9%	36%	61%	3%
32. Modifies design	14%	38%	48%	70%	15%	15%	63%	33%	4%
33. Makes technical report on the design, its tests, and modifications	14%	61%	25%	55%	30%	15%	52%	44%	4%
The technician, upon performing the tasks selected previously, must exhibit a knowledge of:									
35. Mathematics through Algebra							4%	79%	17%
36. Mathematics through Trigonometry							9%	67%	24%
37. Mathematics through Analytic Geometry and Calculus							40%	20%	40%
The technician, upon performing the tasks selected previously, must exhibit a knowledge of basic principles, laws, and concepts of physics including:									
38. Mechanics								92%	8%
39. Heat								81%	19%
40. Sound								80%	20%
41. Light							10%	76%	14%
42. Atomic Physics							10%	45%	45%
43. The scientific method of inquiry							18%	67%	15%
44. Principles of social psychology in maintaining good relations with fellow employees							17%	63%	20%
45. Basic principles, concepts and laws of chemistry								58%	42%
46. Industry's organization and management							5%	55%	40%
47. Principles of industrial economics								47%	53%

TABLE #5
(Continued)

III. EQUIPMENT ANALYSIS

The next few pages contain a list of equipment, tools, and measurements made in the electrical and electronic industries. This list is by no means complete as it is intended to cover the most common types. The list of equipment is divided into the categories of "Communications" and "Industrial". Listed separately, because they apply to both categories, are the test equipment and tools used by the technician.

We did not know which category, "Communications" or "Industrial" was the primary area of specialization by a company. Consequently a choice was made available for one or more categories.

	Please check type			Please check Technician's Activity			
COMMUNICATIONS	Tube Type	Solid State	Microminiature	Tests & Adjusts	Troubleshoots & Repairs	Designs	Uses as an Aid
1. AM Radio	5%	16%	4%	14%	12%		2%
2. FM Radio	4%	16%	5%	16%	14%		
3. HiFi Monaural Systems	4%	7%	2%	7%	7%		
4. HiFi Stereo Systems	5%	9%		11%	11%		
5. Black & White Television	14%	14%	4%	14%	16%		2%
6. Color Television	9%	11%	5%	11%	12%		2%
7. Closed Circuit TV Systems	7%	16%	2%	14%	14%		2%
8. Monaural Tape Players	4%	12%	4%	11%	12%		
9. Stereo Tape Players	2%	4%	2%	7%	4%		
10. Video Tape Recorders	2%	9%	2%	9%	9%		4%
11. Telephone Answering Systems	2%						
12. Citizen's Band Two-Way Radio Systems							
13. Short Wave Communications System	2%	2%		2%	2%		
14. Antenna Rotator Systems	2%	2%		2%	2%		2%
15. Electronic Garage Door Openers	4%	4%		2%	2%		

III. **EQUIPMENT ANALYSIS** (Continued)	Please check type			Please check Technician's Activity			
COMMUNICATIONS	Tube Type	Solid State	Microminiature	Tests & Adjusts	Troubleshoots & Repairs	Designs	Uses as an Aid
16. Intercom Systems	7%	7%		7%	7%		
17. Movie Projectors	2%	2%		2%	2%		2%
18. Power Amplifier Systems	12%	21%	5%	19%	25%		9%
19. Electronic Ignition Systems	2%	4%		2%			2%
20. Inverters		9%		7%	7%		2%
21. Battery Chargers	5%	11%		11%	11%		4%
22. Alarm Systems	5%	9%		9%	5%		
23. Radar Systems	2%	2%		2%			
24. Microwave System	2%	4%	4%	2%	5%		
INDUSTRIAL							
1. AC Motors	5%			21%	26%		23%
2. DC Motors	5%	4%		25%	28%		7%
3. AC Generators	5%		2%	14%	11%		18%
4. DC Generators	2%		4%	14%	12%		18%
5. Alternators	2%		4%	11%	12%		9%
6. Motor Control Systems	9%	7%	4%	26%	30%		11%
7. Generator Control Systems	4%	2%		11%	11%		4%
8. X-Ray Equipment	2%	2%		4%	4%		
9. Synchros		4%		12%	12%		5%
10. Servomechanisms	2%	11%		14%	18%		9%
11. Timers	11%	18%	2%	26%	35%		18%
12. Electric Brake	2%	4%	4%	19%	25%		7%
13. Electric Clutch	2%	5%	4%	19%	28%		7%

III. EQUIPMENT ANALYSIS (Continued)	Please check type			Please check Technician's Activity			
INDUSTRIAL	Tube Type	Solid State	Microminiature	Tests & Adjusts	Troubleshoots & Repairs	Designs	Uses as an Aid
14. Ultrasonic Cleaner	4%			4%	7%		9%
15. Ultrasonic Flaw Detector							
16. Induction Heating				2%	2%		
17. Dielectric Heating							
18. Photoelectric Control	7%	9%	2%	21%	32%		9%
19. Welding Control Systems	2%			2%	5%		2%
20. Electrostatic Percipitator				2%	2%		
21. Ultraviolet Radiators				2%	2%		
22. Strip Chart Recorders	7%	5%		16%	12%		9%
23. X-Y Recorders	2%	5%	2%	7%	11%		14%
COMPUTERS AND RELATED EQUIPMENT							
25. Card Punching Machines	2%	5%	4%	7%	5%		4%
26. Card Processing Machines (sorting, collating, etc.)	2%	2%	4%	4%	4%		
27. Card Readers and Printout	2%	4%	4%	4%	7%		2%
28. Tape Producing Machines	2%	5%	4%	5%	7%		
29. Tape Readers	2%	4%	4%	4%	5%		
30. Tape Storage	2%	5%	4%	5%	5%		
31. Tape Reproducers	2%	2%	4%	4%	5%		
32. Computer Control Counsol	2%	5%	4%	7%	7%		4%
33. Digital Computer	2%	9%	4%	11%	11%		4%
34. Analog Computer		2%		2%	2%		

TABLE #5
(Continued)

IV. TOOLS

1. Needle nose pliers	93%	13. Sheet Metal Tools	47%
2. Diagonal Cutters	91%	14. Allen Wrenches	88%
3. Screw Drivers	95%	15. Wire Gauge	53%
4. Hex Nut Drivers	88%	16. Spot Welder	21%
5. Soldering Gun	93%	17. Vise	77%
6. Soldering Iron	91%	18. Oven	51%
7. Soldering Aid	56%	19. Wire Stripper	93%
8. Heat Sink	68%	20. Chassis Punches	61%
9. Wire Brush	65%	21. Nibbler	44%
10. Tweezers	81%	22. Drill Press	77%
11. Welding Tor	25%	23. Hand Drills	77%
12. Hammer	81%	24. Soldering Pot	54%

V. CHARACTERISTICS MEASURED BY INDUSTRIAL ELECTRONICS TECHNICIANS

1. Acceleration	19%	13. Humidity	39%	25. Strain	23%
2. Altitude	9%	14. Length	25%	26. Stretch	12%
3. Color	18%	15. Level	26%	27. Temperature	65%
4. Counting	39%	16. Light	28%	28. Tension	28%
5. Density	23%	17. Moisture Con.	30%	29. Thickness	51%
6. Dew-point Meas.	19%	18. pH Meas.	7%	30. Turbidity	4%
7. Displacement	28%	19. Pressure	28%	31. Vacuum	28%
8. Electrical Cond.	75%	20. Rotation	49%	32. Vibration	42%
9. Flow	23%	21. Shock	35%	33. Viscosity	9%
10. Force	37%	22. Sound	42%	34. Width	51%
11. Gas Analysis	5%	23. Spectrum	14%		
12. Gloss	4%	24. Speed	47%		

TABLE #5
(Continued)

VI. TEST EQUIPMENT	Please check type			Please check Technician's Activity			
	Tube Type	Solid State	Microminiature	Tests & Adjusts	Troubleshoots & Repairs	Design	Uses as an Aid
1. VOM	32%	37%	2%	30%	37%		70%
2. VTVM	56%	39%	2%	28%	35%		68%
3. Audio Generator	35%	30%		21%	28%		51%
4. RF Generator	19%	16%	2%	12%	11%		33%
5. Marker Generator	14%	9%		11%	5%		19%
6. Sweep Generator	14%	11%		9%	5%		21%
7. Oscilloscopes	58%	44%	2%	30%	33%		72%
8. Tube Testers	33%	14%		21%	18%		51%
9. Transister Testers	11%	42%	4%	18%	14%		56%
10. Capacitor Analyst	18%	19%	2%	11%	11%		42%
11. TV Analyst	4%	4%					5%
12. Color Bar/Pattern Generator	7%	9%		2%	2%		7%
13. Field Strength Meters	5%	14%		7%	5%		14%
14. Grid Dip Meters	25%	4%		5%	4%		19%
15. AC-DC Voltmeters	25%	28%	5%	19%	18%		70%
16. AC-DC Ammeters	21%	28%	5%	18%	18%		74%
17. Ohmmeters	25%	25%	5%	18%	16%		70%
18. Electronic Switches	12%	26%	4%	18%	16%		33%
19. Bridges	11%	25%		26%	14%		60%
20. Square Wave Generator	19%	5%	2%	9%	11%		28%

VI. TEST EQUIPMENT (Continued)	Please check type			Please check Technician's Activity			
	Tube Type	Solid State	Microminiature	Tests & Adjusts	Troubleshoots & Repairs	Designs	Uses as an Aid
21. Decibel Meter	7%	5%		9%	2%		25%
22. VU Meter	5%	5%		5%	2%		18%
23. Wattmeter	12%	21%		19%	12%		56%
24. Instrument Transformer	4%	4%		11%	9%		
25. Growler				4%	2%		11%
26. Compass	7%	2%					7%
27. High Voltage Insulation Tester	9%	2%	2%	11%	9%		32%
28. Prony Brake	2%	4%		4%	5%		12%
29. Tachometer	4%	4%	2%	5%	4%		30%
30. Megger	9%	7%		12%	7%		42%
31. Test Lamp	12%	5%		11%	9%		44%
32. Gieger-Mueller Counter	2%	4%		4%	4%		5%
33. Wave Meter	4%	4%		4%	4%		7%
34. Frequency Meter	17%	16%	2%	11%	5%		42%
35. Noise Generator	9%	7%		9%	4%		16%
36. Electronic Counters	21%	28%		18%	25%		49%